ELECTRICAL ENGINEERING

JUNE 1961
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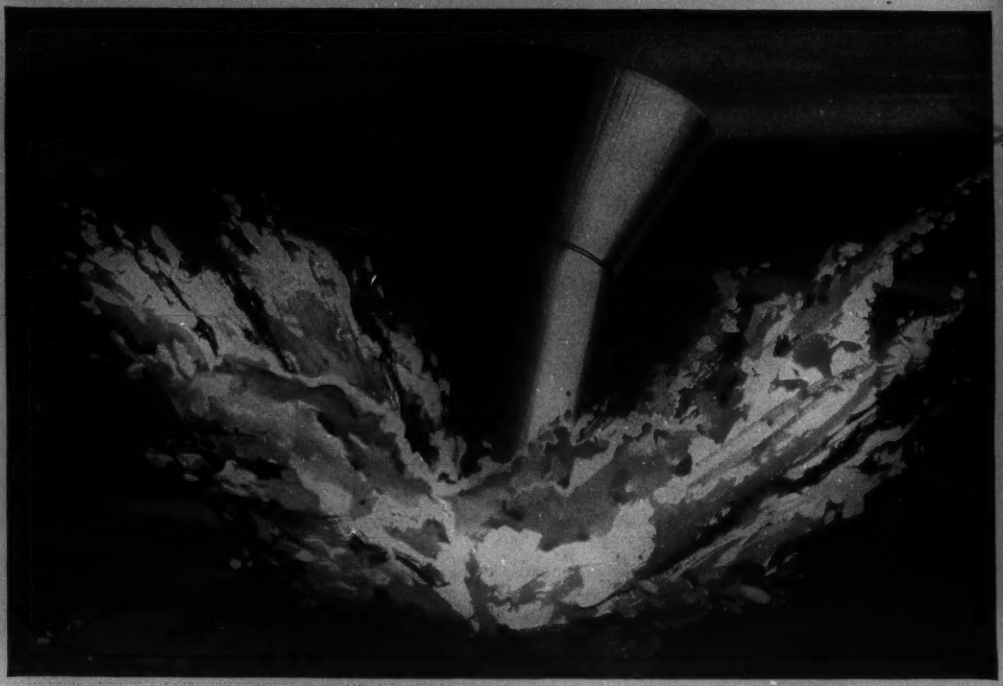

HOW THE OCEAN GREW "EARS" TO PINPOINT MISSILE SHOTS

A quarter of the world away from its launching pad an experimental missile nose cone enters its ocean target area.

How close has it come to the desired impact point?

Where actually did the nose cone fall?

To answer these questions quickly and accurately, Bell Laboratories developed a special system of deep-sea hydrophones—the Missile Impact Locating System (MILS) manufactured by Western Electric and installed by the U. S. Navy with technical assistance from Western Electric in both the Atlantic and Pacific Missile ranges. MILS involves two types of networks.

- One is a long-distance network which utilizes the ocean's deep sound channel. It monitors millions of square miles of ocean. The impacting nose cone releases a small bomb which sinks and explodes at an optimum depth for the transmission of underwater sounds. Vibrations from the explosion are picked up by hydrophones stationed at the optimum depth and carried by cables to shore stations. Time differences in arrivals between these vibrations at different hydrophones are measured and used to compute location of the impact.
- The other is a "bull's-eye" network that monitors a restricted target area with extraordinary precision. This network is so sensitive it does not require the energetic explosion of a bomb but can detect the mere splash of a nose cone striking the ocean's surface—and precisely fix its location.

The universe of sound—above the earth, below the ocean—is one of the worlds of science constantly being explored by Bell Laboratories. The Missile Impact Locating System reflects the same kind of informed ingenuity which constantly reveals new ways to improve the range of Bell System services.

BELL TELEPHONE LABORATORIES

World center of communications research and development

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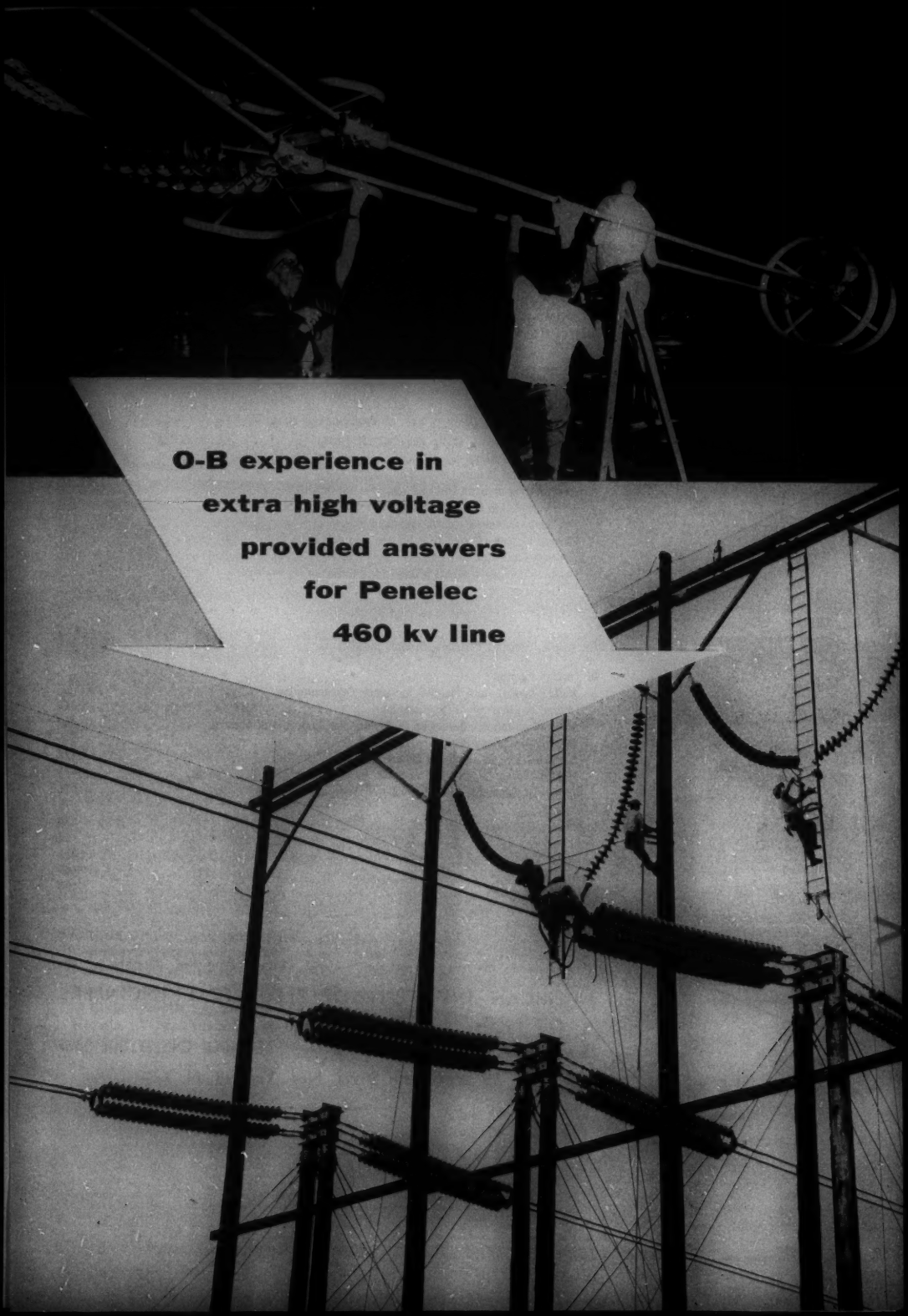
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provided answers
for Penelec
460 kv line

AMERICA'S "BIG-VOLT" LINE protected by ALUMOWELD OVERHEAD GROUND WIRE

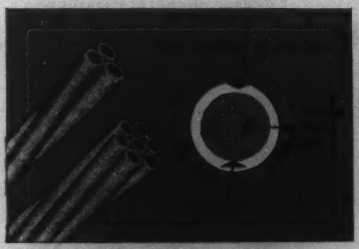
Like the famed "Big Inch" in the oil industry, Pennsylvania Electric Company's "Big Volt," its new 460-KV transmission line, represents a bold step forward in supplying the growing energy needs of America.

To protect the highest voltage operational line in America from lightning and transient currents, Penelec is using Alumoweld Overhead Ground Wire. This dependable, low-cost shield wire has three times the electrical conductance of steel, is just as strong and weighs 18% less. It has the same long life as solid aluminum.

Alumoweld is the result of the first successful cladding of a *thick* layer of pure aluminum over a high-strength steel core. The concentric aluminum covering comprises 25% of the cross-sectional area of each wire. Its high strength-to-weight ratio—higher than any other overhead ground wire—permits stringing with greater mid-span clearance to provide maximum lightning protection. Alumoweld's excellent conductivity assures reliable operation of protective relays and effectively discharges transient currents to ground.

Order Alumoweld Overhead Ground Wire and get Low-Cost, Long-Life Protection for your transmission lines.

For more complete Alumoweld data send for Engineering Bulletin E.D. 3000.



A seven-strand Alumoweld Overhead Ground Wire (7 No. 6 Awg wires), approximately ½-inch in diameter with a breaking strength of over 22,700 pounds, is used to protect the highest voltage transmission line in America.

ALUMOWELD

COPPERWELD STEEL COMPANY

WIRE AND CABLE DIVISION Glassport, Pa.

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Canadian Distributor: NORTHERN ELECTRIC COMPANY LIMITED

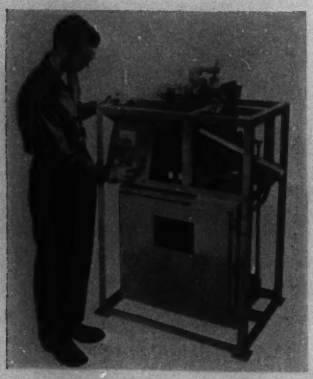
New and Improved Products . . .

Motor Starter Line . . .

A new line of JIC NEMA 12 combination motor starters with quick-make, quick-break fusible disconnects will find a wide range of industrial applications in the automotive, chemical, steel, processing, and original equipment manufacturing fields. The apparatus is particularly adaptable for use in single-motor machinery located where oil or nonexplosive dust is a problem. Unusual safety features stem from the QMQB fusible disconnects equipped with integral rotary handles. These not only eliminate mechanical linkage, but also offer the safety advantages of positive on–off indication and ability to use up to three padlocks on the door, open or closed. *Federal Pacific Electric Co., 50 Paris St., Newark, N. J.*

Electronic Weight Comparator . . .

This fully automatic production-line weight comparing system automates the selection and screening of production parts and materials by rapidly weighing each item individually,



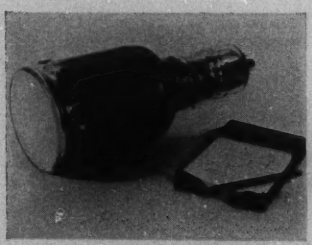
comparing this weight to within ±1 gram of a predetermined proper weight, and then either accepting or rejecting the item depending on how it meets the weight requirement. As presently designed, the system handles items weighing up to 5 pounds. Typical applications include the identification of different metals presented in slugs of similar volumes and the inspection of ball bearing assemblies by weight to determine their completeness. *Atronic Products, Inc., West Conshohocken, Pa.*

Gallium Varactor for Radar . . .

A new gallium varactor, for use as a preamplifier in radar, is expected to increase the effective range of these systems by as much as 50%. Providing low-noise microwave amplification, the varactor has a frequency cut-off of 150 kmc. Devices with even higher frequency cut-offs are in development. This unit employs a reverse-biased p-n junction where capacitance is voltage dependent. Shaped like a miniature rolling pin, the gallium arsenide varactor measures ¼ inch in diameter by 11/16 inch long. *Raytheon Co., Lexington 73, Mass.*

High-Resolution Erasure Tube . . .

A new display storage tube capable of high-speed selective erasure, simultaneous display of stored and non-stored information, and high-resolution light or dark trace displays incorporates a special "dual effects" target employing bombardment-induced conductivity effects. High-energy electrons erase the display, low-energy electrons write stored information, and intermediate energy electrons write non-stored information. Besides the ability to operate in several modes, the tube has resolving power up to three times greater than tubes now in use while maintaining the brightness and half-tone capabilities of coventional tubes. *Hughes Aircraft Co., 2020 Short St., Oceanside, Calif.*

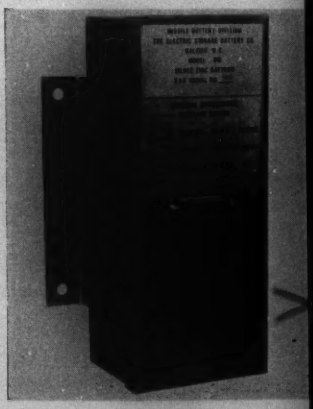


Thermoelectric Experimental Kit . . .

Type *300*, an expanded version of the *K-1*, was designed to obtain empirical knowledge of thermoelectric materials, principles, and technique in a planned and organaized manner. Contained in the kit are typical Frigistor cooling modules of Neelium as well as all necessary hardware to conduct a broad spectrum of basis experiments in thermoelectric cooling and power generation. A 38-page instruction book and lab manual describing the 10 principal experiments is also included. *General Thermoelectric Corp., Princeton, N. J.*

Automatic Battery . . .

A new silver-zinc primary battery that will activate itself within a maximum of 15 seconds was developed as an electric power source for missiles. Designed to provide ample power needed to transmit data from long distances, the 28-volt model *70* battery will discharge for 12 minutes with an electrical load of 5 amperes. The voltage is regulated to limit fluctuation to ±5.4% of the 5-ampere load. After the battery is activated, it will stand ready to deliver power for 10 hours. It can be stored, unactivated, for an estimated 5 years. The 20-cell battery weighs only 4.2 pounds and is 2.44 inches high, 3.19 inches wide, and 7.41 inches long. *Electric Storage Battery Co., P.O. Box 11301, Raleigh, N. C.*



(Continued on page 11A)

New Products

(Continued from page 8A)

Safety Sign . . .

This portable electroluminescent sign with letters almost a foot high that rapidly flash off and on was designed for highway danger areas. Three letters with a transistorized flasher use only 2 watts of power; two standard 6-volt cells will operate a sign of this size for 300 hours. A red reflective material forms a background for the letters so that the sign will continue to be a warning when the batteries fail. *Westinghouse Electric Corp., Box 2278, Pittsburgh 30, Pa.*

Silicon Bridge Rectifier . . .

This low-cost medium-power silicon bridge rectifier is so compact that it can be installed at the point of use, eliminating the need for long d-c

power runs from rectifier to equipment. Average savings of from 50% to 70% in space can be realized with this component, making it ideal for use in battery charging units, d-c motor control drives, laboratory and aircraft power supplies, instrumentation, computers and magnetic amplifier applications. It can also be used in thermoelectric and vibratory equipment. *Semiconductor Division, Syntron Co., Homer City, Pa.*

Readout Photocells . . .

Because of their inherently fast response time (5 to 20 microseconds) this new series of photocells can read 10,000 characters per second in perforated tape or punched card data systems. Available with 5, 6, and 8 to 10 readout positions, each cell generates a current of 350 microamperes for each 0.01 square inch of active cell area when exposed to 1,000 footcandles of illumination. *International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.*

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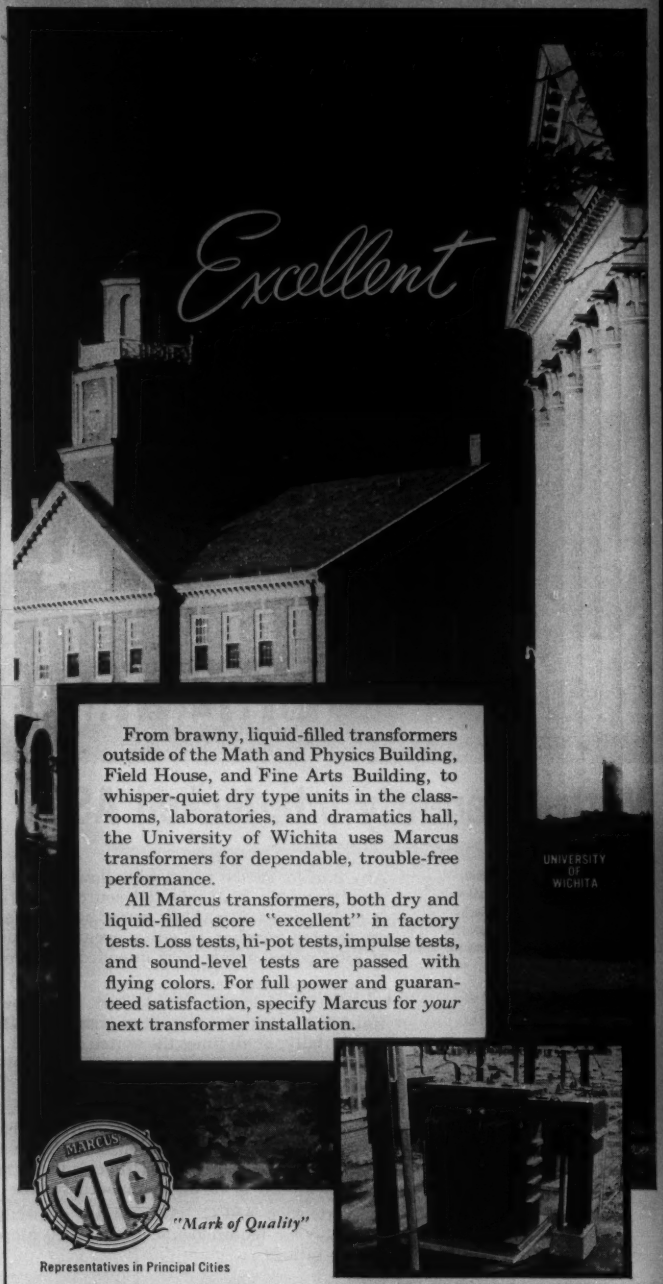

From brawny, liquid-filled transformers outside of the Math and Physics Building, Field House, and Fine Arts Building, to whisper-quiet dry type units in the classrooms, laboratories, and dramatics hall, the University of Wichita uses Marcus transformers for dependable, trouble-free performance.

All Marcus transformers, both dry and liquid-filled score "excellent" in factory tests. Loss tests, hi-pot tests, impulse tests, and sound-level tests are passed with flying colors. For full power and guaranteed satisfaction, specify Marcus for *your* next transformer installation.

1500 KVA OIL FILLED TRANSFORMER

MARCUS MTC "Mark of Quality"

Representatives in Principal Cities

MARCUS TRANSFORMER CO., Inc.

RAHWAY, NEW JERSEY

A COMPLETE LINE OF DRY TYPE AND LIQUID-FILLED TRANSFORMERS THRU 5000 KVA

LOCK OUT POWER TRANSFER PROBLEMS

With Inherently Interlocked ASCO Transfer Switches

A. Normal Position ... Solenoid is not energized. Angular relationship of connecting linkages locks rotating weight and main contacts rigidly in position. Only momentary actuation of solenoid can realign linkages and rotate weight to change switch position.

B. Emergency Position ... After rotation of weight, angular relationship of linkages locks weight and main contacts in new position. Solenoid is no longer energized. Mechanically rugged movement has no hooks, latches, or semipermanent magnets.

Any transfer switch which will allow normal and emergency contacts to open or close simultaneously is a potential source of serious trouble. In the former case the load is disconnected from both power systems, and in the latter, the two power systems are shorted together. In either event the faulty switch actually causes the condition of total power outage it is intended to prevent.

In contrast, the mechanism of an ASCO Mechanically Held Automatic Transfer Switch is inherently interlocked. The powerful movement, shown above, rigidly restricts the switch to one of two possible positions. The movement can not be dislodged accidentally; at all times the switch is locked in position by powerful mechanical linkages which totally eliminate movement or play of the contact arms. Only energization of the solenoid can change the position of the switch.

This unique mechanical locking system constantly maintains heavy contact pressure too, thus minimizing I^2R losses and eliminating accidental contact separation from vibration or other causes. Additional features include: wide break distances; positive make ability; and high short time fault current ratings. Dependability of the entire transfer switch is further enhanced by the rugged, single-solenoid ASCO design.

The extensive ASCO line includes a mechanically held automatic transfer switch to meet *your* requirements: 30 to 2000 amperes ... to 750 volts ... in standard or special ratings.

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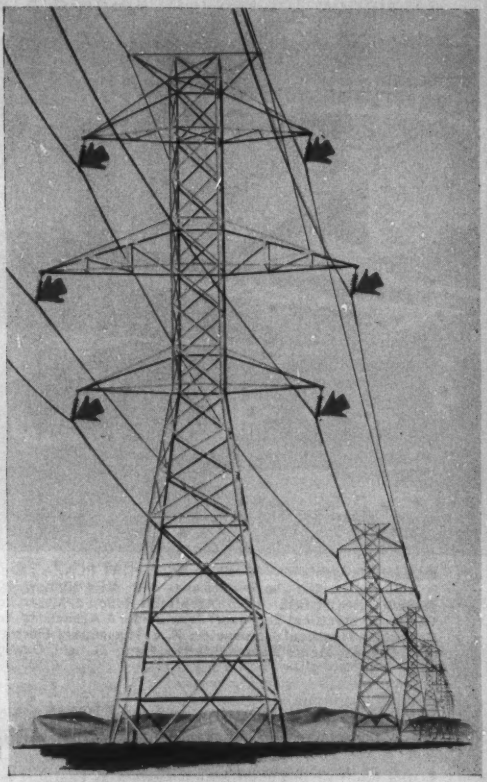
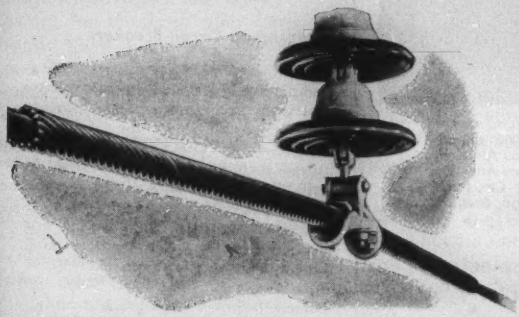
Lifetime protection for less than 1/4 cent per T-Line dollar invested ...with FANNER Superformed* ARMOR RODS

at these vulnerable points





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Top-quality products of the world's FIRST MAKER of machine-formed armor rods . . . Superforms are uniformly strong, dimensionally accurate, smooth surfaced, easy to install. Available for all conductor types and sizes. Learn how little so much extra protection costs. Call today.

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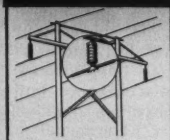
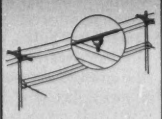
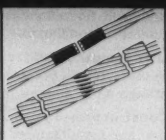


ARMOR RODS . . . Protect long spans at supports

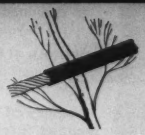


LINEGUARDS . . . Protect short spans at supports

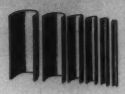
FANNGRIPS . . . For dead-ending strands or conductors



FANNSPLICES . . . For joining or patching strands



Plastic TREEGUARDS . . . Protect conductor surface covering



Plastic KOVER-GUARDS . . . Protect surface-mounted conductors

*A superior forming method in accordance with Patents No. 2,769,478 and 2,588,663—other patents applied for.

THE FANNER MANUFACTURING COMPANY
Brookside Park • Cleveland 9, Ohio

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A-1545A

MEARS low voltage circuit breakers . .

Designed for modern shopping centers

Portland, Oregon's new $5 million EASTPORT PLAZA shopping center is enjoying trouble-free performance with MEARS new 4,000 ampere FUSED CIRCUIT BREAKERS. **Architect:** Robert J. Mayer, Los Angeles, California; **Electrical Engineer:** John Snider & Associates, Los Angeles, California; **Electrical Contractor:** R. E. Huenergard Electric Co., Portland, Oregon; **Mears Representative:** Henry G. Lehl, Oswego, Oregon.

MEARS new 4,000 ampere fused breakers selected to meet Eastport's critical load requirements.

In the heart of this distribution system at Eastport are 2 newly developed 4,000 ampere fused breakers dividing the 8,000 ampere load into 2 subdistribution load centers which include 3 secondary breakers of 2,000 ampere capacity. These electrically operated breakers have a shunt trip in each phase giving protection against "single phasing" . . . when any one fuse is blown, the breaker opens instantly.

F-4 FUSED CIRCUIT BREAKER

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The operating mechanism on all Mears breakers is designed and built for reliability under the most severe operating conditions.

Variety of Basic Frame Sizes . . . Mears low-voltage air and fused circuit breakers are available in 600 through 4,000 ampere frame sizes.

Variety of Construction Types . . . Mears circuit breakers are manufactured to special order for many of the nation's independent switchboard builders in **Fixed Switchboard** mountings, **Plug-In** mountings and **Drawout.**

See the **"MAN FROM MEARS"** in your area . . . or write department EE-6 for our new Circuit Breaker Catalog.

MEARS CONTROLS *Inc.*
13725 S. W. Millikan Way • Beaverton, Oregon

New Products

(*Continued from page 11A*)

1710 Control System . . .

Designed for areas of process optimization, process study, and manufacturing quality control, the system consists of the new *1711* data converter connected to the solid-state *1620* computer. In process study, the *1710* can perform various mathematical analyses such as correlation and regression studies. In process optimization it can improve process performance by furnishing guides to the operator as a result of calculations performed on sampled data. In quality control, the system takes frequent instrument readings of products undergoing final test. The key ability of the *1710* is to sharply reduce the time between the occurrence of disturbances or flaws in a plant operation and initiation of corrective action. *International Business Machines Corp., 112 E. Post Rd., White Plains, N. Y.*

Redesigned Circuit Breakers . . .

The new 13.8-kv apparatus was completely redesigned to incorporate stored-energy closure and provide closed-door drawout for simplified maintenance. Other advanced features include face-wound blowout coils for faster fault interruptions, compact size with low center of gravity, and improved bus design. For maximum safety, a 2-way interlocking system is used during breaker drawout. Compartments have been arranged to provide maximum accessibility to buses, breakers, control wiring, and auxiliary equipment. *I-T-E Circuit Breaker Co., Philadelphia, Pa.*

Automatic Weather Station . . .

Computers are now working for the weather man in this new automatic meteorological station. Known as the *An/FMQ-5*, the system takes meteorological information from both electronic sensing devices and human weather observers and automatically stores, computes, and distributes it as needed over telephone lines or radio. Barometric pressure is measured with a new electronic barometer to within 0.01 inch of mercury, while rainfall is measured by an electronic gauge that presents the output in digital form for input to the computer. The machine computes mean and peak wind speeds, runway visual range, and the 20% and 90% probability point of aircraft approach light contact height. *The Siegler Corp., Olympic Radio and Television Div., Long Island City, N. Y.*

(*Continued on page 24A*)

Value Analysis Fact Sheet

ANACONDA FREE-CUTTING BRASS ROD

Not the plain old work horse many think, it can be produced with a variety of valuable properties—in addition to high machinability—to do many special jobs better, and at lower cost.

For the great majority of high-speed screw machine jobs, free-cutting brass rod is a standard shelf item.

But in an increasing number of jobs, the free-cutting property alone is not enough. Deep drilling to close tolerances, roll-threading, knurling, staking, slotting, etc., call for uniformity in a variety of other property combinations.

Fortunately free-cutting brass is a unique "on the fence" alloy (see Metallurgical Comment at the right) that can be adapted to answer these new demands—help screw machine operators meet increasingly rigid requirements and utilize cost-saving practices.

Specialized applications. Over the past several years, Anaconda American Brass has introduced several refinements into the usual mill practice for free-cutting brass and has developed different rods for specialized applications. In most instances, these rods will still meet ASTM and Government specifications.

Chip breaking. For the user who demands a rod with uniform ability to break up into small chips, an alloy is supplied which regularly contains substantial quantities of beta. This, because it is brittle at room temperature, adds to the chip-breaking ability of the lead already there. This rod is, therefore, particularly good for high-speed forming and drilling applications. On the other hand, it is the least ductile and can therefore be formed and headed to the least extent.

Cold forming. The usual and more numerous special applications require uniform ability to be cold-worked—as in roll-threading, knurling, heading, and other deforming. Properties of these special rods are refined by heat treatment or special drawing operations so that the rod can be consistently cold-worked. Normally, there is little sacrifice in machinability, but there is some loss in the ability of the rod to break into small chips.

Deep drilling. In small rod particularly, there has been an increasing demand for material that can be drilled to close tolerances. Special drawing and heat treating practices were developed to produce a rod which performs uniformly, even in such exacting applications as ball point pen tips.

High Strength. And for those applications calling for uniformly higher strength than the usual material, there is a rod produced by special drawing practices.

Technical assistance. If you have a special problem—whether it involves a variation of free-cutting brass or another free-cutting or engineering copper alloy—call in your Anaconda American Brass representative. He'll make available to you the experience and services of metallurgical and mill specialists. Or write: Anaconda American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6148

FOR MORE INFORMATION about Anaconda Rods for Screw Machine Products—including physical properties, mechanical properties, composition and machinability — write for Publication B-14. Address: Anaconda American Brass Company, Waterbury 20, Connecticut.

Metallurgical Comment

Free-Cutting Brass can provide relatively wide variations in temper and ductility within the range of composition defined in ASTM and Government specifications (60 to 63% Cu, 2.5 to 3.7% Pb, remainder Zn).

In the commonly available rod temper, referred to in ASTM specifications as "half hard" and more commonly in the trade as "hard," tensile strength may range from 50,000 to 70,000 psi, depending on the rod size and the manufacturer.* And there can be a comparable variation in cold-working properties.

Here's why. The range of 60 to 63% copper was selected for free-cutting brass because it is the lowest which can be used to produce an alloy that can be hot-worked readily and also cold-worked. This means a brass that can be hot-extruded down to small sizes—and that later can be cold-worked to a modest degree.

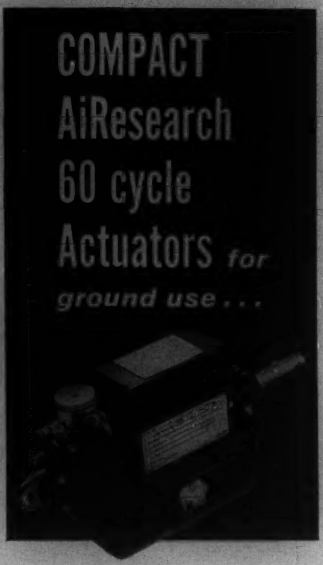
In more technical terms, free-cutting brass is at the transition point between the alpha phase (the ductile form of the alloy) and the beta phase (the form that's hard and brittle at room temperature but readily worked when hot). Thus, relatively minor changes in composition and fabrication practices can make substantial shifts in the proportion of alpha and beta grains—hence in strength and ductility. Various combinations of these properties can be maintained uniformly by careful control of mill practices.

Free-cutting property of the alloy is, of course, provided by lead dispersed through it—and is not materially affected by changes in other properties.

Standard Anaconda Free-Cutting Brass-271 has a composition of 61.50% Cu, 3.25% Pb, 35.25% Zn. This composition and the mill procedures used are designed to provide a rod which will fit the great majority of high-speed screw machine work.

*In special hard temper the tensile strength of small sizes will approach 90,000 psi.

ANACONDA®
FREE-CUTTING ROD
Anaconda American Brass Company



Inexpensive, lightweight 60 cycle motor driven actuators with integral magnetic brakes* are now being manufactured by AiResearch for ground radar, ground support and shipboard use.

Unequalled in 60 cycle performance, these extremely compact, lightweight actuators range from fractional hp motor size up to any desired hp in single phase, two phase and three phase design for a wide variety of applications.

The above-pictured actuator is used in a ground radar system. It is driven by a single phase 60 cycle ac fractional hp electric motor and can be furnished with a feedback potentiometer for use in servo applications. The entire unit weighs only 2½ lb. and is rated at 200 lb. operating load.

OTHER ELECTROMECHANICAL COMPONENTS AND SYSTEMS

A C and D C Motors, Generators and Controls • Static Inverters and Converters • Linear and Rotary Actuators • Power Servos • Hoists • Temperature and Positioning Controls • Sensors • Programmers • Missile Launchers • Radar Positioners • Power Supplies • Williamsgrip Connectors

Your inquiries are invited.

* patented 60 cycle operated magnetic brake

THE GARRETT CORPORATION

AiResearch Manufacturing Division

Los Angeles 45, California

New Products

(*Continued from page 16A*)

Shielded Winding Transformer . . .

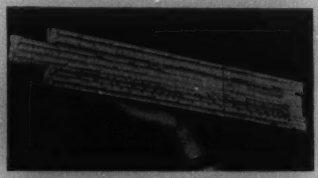
A transformer has been designed for use in hazardous locations defined in Class I, Division 1 of the National Fire Prevention Code. A simple shield between input and output windings permits grounding. Applications range wherever hazardous concentrations of flammable gases exist, such as hospital anesthetizing areas or where volatile liquids are transferred from one container to another. The new line is available in ratings from 100 watts to 50 kva, 120-volt input, 120-volt output. *Acme Electric Corp., Cuba, N. Y.*

Electronic Governor . . .

A new heavy-duty electronic governor for precise control of shunt wound d-c motors up to 1 hp will maintain constant speed at any selected value despite variations in load, line voltage, or motor temperature. Operating from a 230-volt 50- to 60-cycle single-phase line, the unit is available either as a stripped chassis suitable for incorporation into other equipment, as a rack mounted unit, or as a self-contained unit enclosed in a cabinet. *Linde Co., Div. of Union Carbide Corp., 270 Park Ave., N. Y. 17, N. Y.*

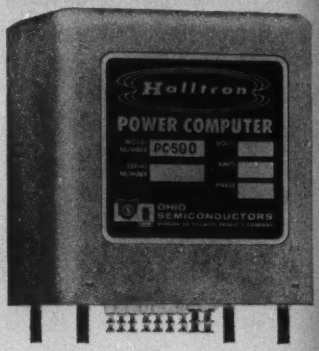
Radiation Slide Rule . . .

Providing a major reduction in the number of steps formerly required to obtain radiation black body information, direct reading of values in both watts and photons per square centimeter can be made with one setting of the slide or cusor. Twin temperature scales provide readings in degrees centigrade or absolute over a range of —180 to 10,000 C. Quantities such as radiant flux density in a given wavelength or the corresponding quantities expressed in photon units may be obtained readily for a black body over a range $\lambda T = 2 \times 10^3$ to $\lambda T = 4 \times 10^6$ micron-degrees with an accuracy of about 1%. The *F5100* has seven scales on the stock and six on each face of the reversible slide. *Walsh Engineering Sales Co., 718 Manchester, Suite 5, Inglewood, Calif.*



Power Computer . . .

The *PC-500* is an accurate, wideband, rugged, Hall effect power computer operating without moving parts and producing a d-c voltage output proportional to true power. The high



output voltage, a linear function of power transmitted, is temperature insensitive over a wide temperature range and requires no amplification to drive many recording instruments or meters. Its ability to compute power over a wide frequency range of from 50 to more than 1,000 cps makes it a versatile instrument for most types of power systems. The time-dependent characteristics of the power waveform are accurately reproduced at the output terminals for display on an oscilloscope to show special waveforms, transients, system irregularities, or to indicate, to record, or to control average power. *Ohio Semiconductors, 1205 Chesapeake Ave., Columbus 12, Ohio.*

Phone Scrambler . . .

Party-line eavesdroppers, wiretappers, industrial spies, and plain snoopers were dealt a fatal blow when this portable telephone "scrambler" was first introduced. Now conversations over FM mobile radio and radiotelephone networks can be made equally secure. Of interest to law enforcement agencies, petroleum industry, boat and ship owners, and other industrial users of mobile radio where voice security is a factor, model *106* plugs into any standard FM mobile radio at fixed stations and mobile units. Resembling a slightly oversized telephone handset, the device uses a transistorized circuit and weighs 24 ounces. *Delcon Corp., 943 Industrial Ave., Palo Alto, Calif.*

AIEE and Appliance Engineering—For What and for Whom?

M. A. FULLER
MEMBER AIEE

Some of the basic assumptions of the AIEE are re-examined to help the engineer obtain a true perspective of his social contribution. His responsibilities to the public, his profession, and company are examined so that his activities can redound to the mutual benefit of all concerned.

DURING the past 2 years in which I served as chairman of the AIEE Domestic Appliance Subcommittee, I repeatedly found myself trying to answer the questions: What are the basic assumptions behind AIEE and in particular domestic appliance engineering?; For what purpose does the Institute and the Domestic Appliance Subcommittee exist?; For whom do these organizational entities exist?

AIEE'S "PURPOSE" AND DIRECTION

AIEE's constitution states that the Institute's purpose is "the advancement of the theory and practice of electrical engineering and of the allied arts and sciences and the maintenance of a high professional standing among its members." This has become a cliché. I suggest that its suitability in expressing our basic assumptions is entirely dependent upon the depth of attitude and the breadth of the philosophical underpinnings of those concerned. Advancement means the act of bringing forward; or accelerating the growth or progress of something. The connotation with respect to the question "for what" purpose do we join together would be that we joined deliberately to explore the future. At AIEE meetings, in our publications, or merely in conversation, members should look closely to see if the underlying thread through these activities is that of exploration of the future. Dr. Arthur Bronwell, president of Worcester Polytechnical Institute suggests that there is no organized forum where research scientists, and engineers, can deliberately explore the future in a philosophical sense. He said something like this: Almost everything presented to the meetings of the scientific and engineering societies is past tense. A researcher contemplates the studies and reports on this or that at a scientific and engineering society meeting, after which it is duly published in the society journal. With rare exceptions, there is no attempt to project to the future philosophically, and one who indulges in this kind of excursion may find himself regarded as a charlatan.

The next question to ask ourselves is, "What is it that we are advancing?" The AIEE constitution says that it is "electrical engineering and the allied arts and sciences." The definitions of each of these words are certainly such that when taken together they cover an extremely wide area of human activity. In considering our basic assumptions it is important to keep in mind that the objective of our profession is gaining and using knowledge to make the energies and materials of nature useful to people. To get this in the proper perspective, it means doing the following things in the form of a tightly integrated effort: (a) discover, create, and define consumer needs; (b) study and observation of nature's energy and materials and the organization of these studies into testable hypotheses; and (c) through analysis, creativity, and dexterity utilize energy and materials to satisfy customer needs.

When we consider the adjective electrical, let us consider it as referring to one of the fundamental parameters of the enegry and materials of nature. To define it in any less broad sense is to suffer from myopia which will place our activities in the shadow of obsolescence. The Institute has been criticized for limiting its activities to the narrow sense of "the electricity of the electric utilities." Theodore Levitt writing on the subject of marketing myopia in the *Harvard Business Review*[1] used electric utilities as an example to point up the need for clear objectives. He said,

> "This is another one of those supposedly 'no-substitute' products that has been enthroned on a pedestal of invincible growth. When the incandescant lamp came along, kerosene lights were finished. Later the water wheel and the steam engine were cut to ribbons by the flexibility, reliability, simplicity, and just plain easy availability of electric motors. The prosperity of electric utilities continues to wax extravagant as the home is converted into a museum of electric gadgetry. How can anybody miss by investing in utilities, with no competition, nothing but growth ahead?
>
> "But a second look is not quite so comforting. A score of nonutility companies are well advanced toward developing a powerful chemical fuel cell which could sit in some hidden closet of every home silently ticking off electric power. The electric lines that vulgarize so many neighborhoods will be elim-

Essentially full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., Jan. 29-Feb. 3, 1961.

M. A. Fuller is with the Whirlpool Corporation, St. Joseph, Mich.

inated. So will the endless demolition of streets and service interruptions during storms. Also on the horizon is solar energy, again pioneered by nonutility companies.

"Who says that the utilities have no competition? They may be natural monopolies now, but tomorrow they may be natural deaths. To avoid this prospect, they too will have to develop fuel cells, solar energy, and other power sources. To survive, they themselves will have to plot the obsolescence of what now produces their livelihood."

THE PROFESSIONAL ATTITUDE

LET US NOW TURN from examining our basic assumptions about our sphere of interest to examining our basic assumptions about the method by which we pursue our aims. This is the part of the AIEE constitution which deals with the "maintenance of a high professional standing among its members." It is my opinion that our basic assumptions in this sphere have to do with attitude and with recognition. It is my opinion that recognition comes about when something professional has been accomplished. As we attempt to satisfy human needs in the context of family living, is it professional to offer to the housewife a gadget to keep the frost off of the evaporator coils of the refrigerator which functions everyday, frost or no frost, and whose very function hastens the spoiling of meat? Is it professional to offer her a new trim on a dishwasher when what she wants is something that will clean the pots and pans? Is it professional to offer her the same old appliance year after year with the only probability for the future being new trim or production refinements? Rather, is this not the behavior of a technician who puts on rubber gloves because he has a leaky fountain pen? I suggest to you that the professional attitude is frankly offering the best over-all solution we have to family living needs today while at the same time looking to the future in terms of an integrated system suitable for social and living behavior 5 to 20 years hence.

On the matter of professional attitude, I would suggest that it is largely characterized by a deep sense of obligation. Dean Justin Miller of the Duke University Law School[2] elaborated on the nature of this obligation when he said: "One way of testing the nature and extent of the (professional) obligation is to consider the difference between the profession and the business. In business transactions, each participant is assumed to be equally well informed and equally able to hold his own in the give and take of trade and barter. The well known maxim of the law warns: 'Let the buyer beware.' On the other hand, the member of a profession is assumed to be better informed than the client or patient whom he serves and stands in a position of champion or protector."

COMPANY RELATIONSHIP

THE EXAMINATION thus far of our basic assumptions within the context of our technical society raises the question, "What about that other organizational relationship with which I am involved in pursuit of some of these goals and aims—the company with whom I am employed?" With a few definitions, let us examine that interrelationship. First, it is important that we understand that a corporation is basically a pool of resources functioning together through an administrative framework. Second, that the profit that a corporation generates is only one of several fundamental quantities that serve as a tool in its continued existence. Third, that nothing will happen in a corporation except that a group of people has a goal and a desire "to do something" which satisfies a human need.

In looking at both our technical society and our company relationships, one further concept is important to understand the commonness of objectives which engineers seek through the corporation and through the technical society. That is, we must clearly see the identity of the client or customer whom we as professionals serve. In the context of our engineering within a corporate structure, do not be misled by the concept that it is "they" who are in business and "I" in the profession but rather that it is "we of the corporation" who serve the public at large in their family living circumstances.

FULL TECHNICAL GROUP PROPOSED

WITHIN THE CONTEXT of these basic assumptions, I have proposed to the AIEE Domestic and Commercial Applications Committee that the objectives of domestic appliance engineering could be best served by a full technical group of the Institute. I am well aware that many engineers abhor the managing and administrating necessities entailed in an organizational framework. A recent article in the Harvard Business Review[3] discussed the character of managerial methodology which appears to be at variance with technical professional ethics: "Summarized briefly the nine rules of a manager indicate that he seldom seeks advice from others, forms alliances or cliques with other managers, never completely commits himself to one side of an issue, regards the withholding of information as an important tactical weapon, makes necessary compromises with his tongue in cheek, is adept at dragging his feet when faced with an impalpable order, is an artful actor on occasions, will make an uncertain decision with a show of confidence and is always the boss."

It is this writer's opinion that these circumstances of behavior only exist when our technical society or our corporations are without a clear objective. Without an objective, the organizational and administrative framework tends to become an end in itself. To make our aims and goals crystal clear, I would like to go beyond our basic assumptions and suggest the following:

1. That the proposed committee's activities be geared to the concept of family living services rather than to specific household appliances as we know them today.
2. That every meeting of this group be permeated with the thought that it is a forum for exploration, in a philosophical sense, of family living in the future.

3. That this group bend every effort to influence more college students towards careers in our sphere. Two of the ways that this may be done are: (a) By organizing and financing a speaker's bureau for Student Branches of AIEE; and (b) By promoting funds for AIEE awards and stipends for graduate students in electrical engineering and its allied arts and sciences for any significant project or project proposal which may increase the body of knowledge that would aid in providing family living services.

4. That the proposed committee develop a mechanism and leadership for carrying on broad research projects in our field of interest of such breadth that they would tend to be impractical, even if financially feasible, for the separate corporations to pursue independently.

5. To interpret our aims, objectives, and accomplishments for the layman in terms that he can understand and to see to it generally that he is informed as to what he may expect in terms of family living services from devices and systems he may buy.

6. That technical paper presentations be promoted which serve as a record of scientific progress and state-of-the-art advances in providing family living services.

Should there be protests that these proposals shoulder responsibilities far beyond those which bring us together in a technical society, recall that engineering in the sense of harnessing and transforming nature for the service of man is not a young profession uncertain of its responsibilities—it is as old as civilization. It is well known that the ancient's new geometry and mechanics erected what we still recognize as some magnificent engineering works—the Roman roads, irrigation projects and aqueducts, the great wall of China, and the mighty pyramids of Egypt. But they also recognized the tremendous responsibility that practitioners of the arts and sciences had toward their fellow men. The Babylon code of Hammurabi dated about 2100 BC held that: "In the case of collapse of a defective building, the architect is to be put to death if the owner is killed in the accident; and the architect's son, if the son of the owner loses his life."

If it is felt that providing leadership for large scope research projects is wholly the prerogative of the corporate relationship, consider the words of R. E. Brooker, President of Whirlpool Corporation:[4] "I have the feeling that the leadership for a combined project to develop thermoelectric refrigeration might originate with the engineers. There is a subject that is beyond the full comprehension of most sales and top management groups—one that can be . . . harmed by . . . controversial publicity—and with a potential product that would prosper best with full industry support."

If there is concern as to what graduate students might find for study or from whence the funds would come, consider these facts:

1. System concepts have become quite prominent in some specialized fields of our profession, yet what is known beyond utility annual load curves or demand factors about the functional organization and co-ordination of family facilities with respect to their behavioral pattern? Or for that matter, considering a small segment of the residential domain in a given appliance as we know it today, what is there to suggest that the system concept has been applied: or has, in truth, the case been one of tinkertoy pieces assembled into an energy control and utilization device?

2. What is known about the various segments of the electromagnetic energy spectrum that influence the change of state in food cells from "raw" state to the state we are pleased to call "cooked?" Isn't it rather the case that in either the conventional oven or an electronic oven we throw energy around in a shotgun fashion and hope that if the shots scatter wildly enough the job will be done.

3. Chemists tell us that the ionization state of a cleaning bath for clothes is definitely a factor in the removal of particulate matter in soiled garments. Yet what are we as engineers doing to follow up and examine the probable charge states in soils bound in garments and methods of removal?

4. Funds have been offered to AIEE for at least one graduate student stipend award. The proposal is unique to AIEE awards, in that it is specifically aimed at the graduate student: it provides for his time and the facilities to bring his hypothesis and experimental work to a complete full demonstrative state, and it makes such work available for display and dissertations at colleges and universities.

SUMMARY

To sum up, I would suggest that our aims and goals are:

1. As engineers, to make nature's energy and materials beneficial to people.

2. As a technical society, to provide a forum for exploration of the future for better services to man through electrical engineering and its allied arts and sciences.

3. As a technical committee to translate technical and theoretical accomplishments to facilitate solutions to better family living through a program of enlightenment and greater philosophical depth.

4. As professionals to undertake our activities with full recognition of our relationship to, and influence upon corporate objectives within our industry such that each can enhance the other.

Thus may we get on with the business of our chosen careers.

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2. Address to 30th Annual Congress on Medical Education, Licensure, and Hospitals, Justin Miller. 1934.

3. Thinking Ahead, S. B. Miles, Jr., T. E. Vail. *Harvard Business Review*, vol. 38, Jan.-Feb. 1960, p. 150.

4. Innovation the Lifeblood of Engineering, R. E. Brooker, AIEE Appliance Technical Conference, Mansfield, Ohio, May 10, 1960.

Transformer Invented 75 Years Ago

A. A. HALACSY
MEMBER AIEE

G. H. von FUCHS
AFFILIATE AIEE

Last year marked the 75th anniversary of the first commercial installation of the transformer. In this article a brief history of the early days of the transformer's development is presented.

ON MAY 1, 1960, the electric power industry celebrated an important anniversary; 75 years before, the first commercial, practical transformers, invented by K. Zipernowsky, M. Déri, and O. T. Bláthy (Fig. 1), were put into service at the Hungarian National Exhibition in Budapest.

The most fundamental features of their invention were closed magnetic circuits and the parallel operation of transformers. The principle of electromagnetic induction had been discovered independently by Sir Michael Faraday[1] on August 29, 1831, and by Joseph Henry.[2,3] Faraday's device was a kind of primitive pulse transformer in that he opened and closed a d-c circuit, no alternating current having been available at that time. It was, however, a 2-winding device wound on a closed core. At the Academy in Albany, N. Y., Henry drew a spark by interrupting a single coil; see Fig. 2(A). In 1836, C. J. Page, in Washington, D. C., produced the first autotransformer when he discovered that such sparks can be produced between any tappings of a coil if its circuit is interrupted at any point; see Fig. 2(B). The following year, N. J. Callan,[4] an English priest, divided Page's coil into two parts without any galvanic connection between them. Interrupting the circuit of half the coil, he produced sparks between the ends of the other half; see Fig. 2(C). This 2-winding transformer was the logical end of a chain of experiments. All these devices worked with interrupted direct current and produced sparks only for experiments.

In order to obtain a more powerful spark, Cromwell Fleetwood Varley[5] reversed the direction of the direct current at each switching, thus approaching an a-c operation when alternating current was not yet available; see Fig. 2(D).

Hardly anything else could be accomplished until the dynamoelectric principle was discovered. After that, Sir W. Grove[6,7] in 1868 was the first to connect an a-c source to one coil of an inductor which had two coils on the same iron core; see Fig. 2(E). In the following year, numerous patents were issued for the use of open iron-cored inductors with two coils.

It was a little-known American genius, J. B. Fuller,[8] who would have been credited with the invention of our present-day transformer and distribution system had he not died prematurely. He confided his ideas to his foreman just before his death and his notes were found shortly afterward, in February 1879. They were not appreciated at that time and, of course, they have not been incorporated in any practical device. He proposed the use of a closed iron core, and the connection of the primaries of the transformers in parallel, not in series as most of the experimenters had done.

On September 13, 1882, Messrs. Gaulard and Gibbs filed for the English Patent no. 4362 for inductors and for an electric system supplied by inductors. They demonstrated this system first in 1883 at a small electrical exhibition in the Westminster Aquarium in London, England,[9] then on the Metropolitan Railway in London[10] in the same year, and at an exhibition in Turin, Italy, in 1884.[11]

It was surprising that their inductors or "secondary generators," as they called them, had an open iron core. The voltage was controlled by pushing in and pulling out this core. It was even more surprising that they insisted on the series connection of the primaries, although Maxwell had proved in 1865[12] that the secondary voltages cannot be controlled independently if the primaries are connected in series.

It was rather fortunate that the Turin Exhibition in 1884 was visited by three young engineers, Max Déri Otto Bláthy, and Karl Zipernowsky, from the electrical department of the Ganz factory in Budapest, Hungary. They recognized the great disadvantage of the open

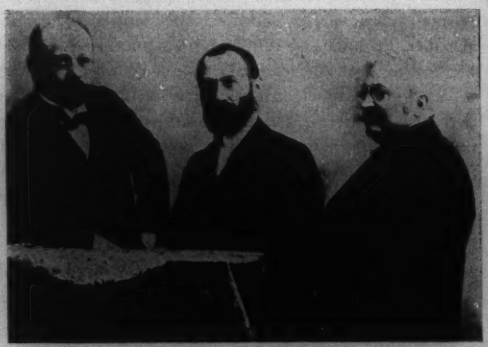

Fig. 1. The inventors of the transformer: Déri, Bláthy, Zipernowsky.

Revised text of paper 61-18, presented at the AIEE Winter General Meeting, New York, N. Y., Jan. 29–Feb. 3, 1961. Recommended for publication by the AIEE Transformers Committee. Published in AIEE *Power Apparatus and Systems*, June 1961, pp. 121-28.

A. A. Halacsy is with the Federal Pacific Electric Company, Newark, N. J.; G. H. von Fuchs is a consulting chemist and chemical engineer, Belmont, Mass.

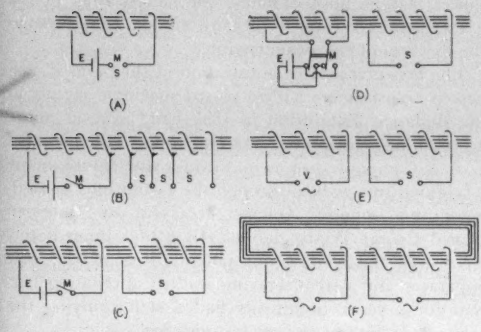

Fig. 2. Development of the concept of the transformer.

A—Henry, 1832
B—Page, 1836
C—Callan, 1837
D—Varley, 1856
E—Grove, 1868
F—Déri-Bláthy-Zipernowsky, 1884

iron core and the series connection of the primaries of the Gaulard–Gibbs system.

It is interesting to note that when Bláthy asked Gaulard why he did not use a closed iron core, the latter replied that this would have been harmful and uneconomical.[13] Returning home, they started work on some improvements, and the August 7, 1884, page of the laboratory journal of Ganz and Company[14] contains the first written notes on their experiments with a closed iron core.

During the winter of 1884, Déri demonstrated their invention at the Vienna Trade Association. Their experiments resulted in two patents in Austria, no. 37/101, filed on January 2, 1885,[15] and no. 35/2446, filed in February 1885;[16] see Fig. 3.

According to the transformer-calculation sheets of Ganz & Company, transformer no. 1 was shipped on September 16, 1884. This single-phase shell-type transformer was rated 1,400 watts, 40 cps, 120/72 volts, 11.6/19.4 amperes, and turns ratio 1.67:1. Its core was made of iron wires; see Fig. 4.

Four more transformers of this type were shipped during 1884. Two of these were for their own factory, one for the Arpadmalom flour mill in Budapest, Hungary, and one for Sevastopol, Russia.

Their chance to apply their new apparatus and system came at the Hungarian National Exhibition in Budapest in May 1885.[14,17-19] A single-phase machine supplied the energy. The terminal voltage of the machine was 1,350 volts and it supplied alternating current at 70 cps. The generator voltage was transformed by 75 shell-type transformers to the voltage of the 1,067 Edison lamps which illuminated the exhibition. Seventy-five years ago, on May 1, 1885, the generator was started, the system switched on, and the light of 1,067 incandescent lamps illuminating the Budapest Exhibition announced to the world that the closed iron core parallel-connected transformer had become a reality.

The energy flowed through these 75 transformers continuously from May to November 1885, when the exhibition closed. These devices, first called "transformers" by Déri, Bláthy, and Zipernowsky, were a tremendous step forward from the old spark-producing inductors and from the Gaulard–Gibbs open iron core secondary generators; see Fig. 5. The system in which these transformers were connected in parallel made regulation of a transformer load independent of the load of the other transformers, and made the distribution of electric energy through transformers practical. The closed iron core decreased to practical values the magnetizing current, reactance, copper losses, temperature, and regulation, and increased the efficiency.

Without the closed magnetic circuit and parallel operation of transformers, we would not have electrical distribution today, just as we would not have electric generation without the invention of the dynamoelectric machine.

A new section of the same exhibition was opened during the summer of the same year. Its illumination was supplied from another network, powered by a smaller machine at 42 cps and in parallel with another group of four core-type transformers. The low frequency of 42 cps was chosen to avoid damaging arc lamps supplied by the same network and also because the product of the integers 1 to 7 and the number of poles of practical machines could be constructed to result always in 5,040 changes per minute.

The August 8, 1885 issue of the *Electrical Review*[18] reported as follows:

"These figures show that electricity is represented at the Buda-Pesth National Exhibition by such an imposing quantity of light as has never (not taking into account the special electrical exhibitions of the last two years) been, even approximately, equalled in any other exhibition . . . It is not solely on account of the splendour with which this branch of industry is represented that the Buda-Pesth exhibition is so particularly interesting, but more especially in consequence of the fact that a new system of distribution of the light has there been inaugurated, which, according to the experimental results obtained, bids fair to mark an epoch in the history of the electric light, as being calculated to overcome all the obstacles which thus far hindered, or in many cases rendered impossible, the establishment of central stations for the electrical illumination of towns. This system is based on the use of induction apparatus as the current distributing medium between the generating dynamo machine and the lamps. The function of those induction apparatus is to convert currents of high tension, which can be easily and cheaply conducted over great distances, into currents of low—absolutely safe—tension, as is essential for the

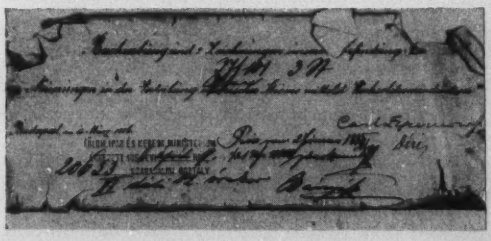

Fig. 3. First patent filed for a transformer in Austria, January 2, 1885.

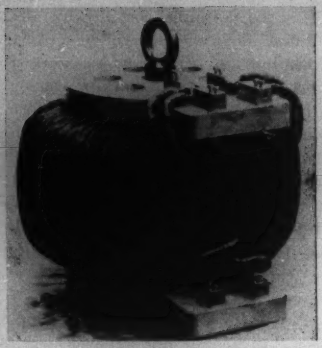

Fig. 4. Transformer produced in 1884.

illumination of incandescence of dwellings and other establishments. In this way it becomes possible to conduct the current from one central station to many consumers, even over very great distances. This system is also specially adapted to the supply of a very variable demand which is of the greatest importance . . .

"The installations of the glow light at the Buda-Pesth exhibition form an interesting example of the Zipernowski-Déri system of arranging a central station for the illumination of several establishments at different localities of a town."

From July to the fall of 1885, the three engineers showed their system at the Inventors Exhibition in London, England,[20] and at a similar demonstration in Antwerp, Belgium.[14] The demonstration in London was a part of the Edison and Swan United Electric Light Company's exhibit, consisting of a pair of 10-hp transformers (supplied by a self-excited alternator) working parallel and reducing the voltage from 1,000 to 100 volts.

In March 1885, Zipernowsky and Déri took out a British patent for the transformer system[21] and in April they took out a British patent for a transformer with a closed magnetic circuit.[22]

The fruits of the first application at the Budapest Exhibition soon ripened. Before the exhibition closed, the first foreign order arrived, on Nov. 18, 1885, from Gebr. Troller & Company, in Thorenberg, Switzerland.[14,23] It was for three water-turbine-driven 42-cps generators, 100-hp each, generating 2,000 volts. The electric energy was transmitted for a distance of 7.2 kilometers, where seven parallel-connected transformers, 7 kva each, with closed magnetic circuits, stepped down the voltage for 200 incandescent lamps, 10 candlepower each, for the illumination of two hotels, the Schweizerhof and the Luzernhof in Lucerne, and two small villages, Rothen and Kriens. At a distance of 7.4 kilometers was another 1.5-kva transformer for 40 lamps in the mill of Gebr. Troller & Company. All these installations were commissioned in April 1886 and were in use for many years.

The second order, placed by the Societa Italiana Generale Edison, was for the illumination of the Teatro de Verme in Milan, Italy.[14,23] Energy at 2,000 volts was supplied from two a-c generators, each built directly on the axis of a 100-hp steam engine. At the Edison Power Station, approximately 500 meters away in Via S. Radigone, the rotor of these alternators served also as the flywheel of the steam engine.

The first practical demonstration of the parallel connected transformers with a closed magnetic circuit at the Budapest Exhibition in 1885 had, however, more far-reaching consequences than the orders which flooded Ganz & Company. Just as in Turin a year before, many foreign visitors walked through the exhibitions in Budapest and London. Among them was an American named George Westinghouse. His genius immediately recognized the tremendous potentialities of the new apparatus and system. Having studied alternating current for 2 years, he already had a staff studying the various methods of electric transmission.

He concluded that what he saw in Budapest and London was the solution to his problem. It did not take long for him and his associates to work out a system suitable for conditions in the United States, and the electric lamps glowing brightly in Great Barrington on March 20, 1886, announced the real beginning of the electrical age in America.

Appendix

First patents filed in the United States for an electric distribution system with transformers having paralleled

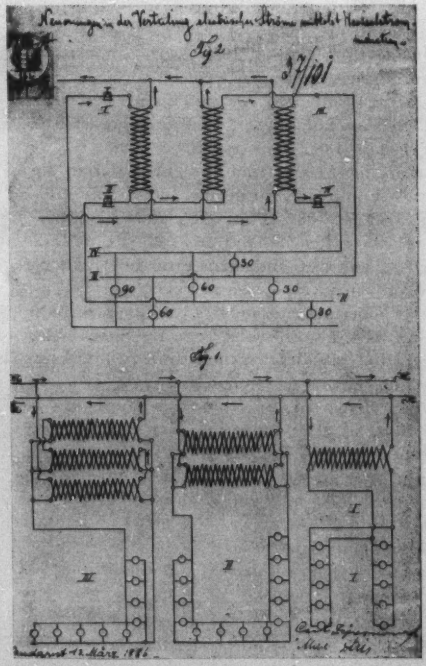

Fig. 5. The patent filed for parallel operation of transformers in Austria, January 2, 1885.

primary windings were no. 392,090, September 2, 1886, by K. Zipernowsky, M. Déri, and O. T. Bláthy; and nos. 399,639, November 23, 1886, 404,139, February 28, 1887, and 373,037, March 9, 1887, all by George Westinghouse, Jr., Pittsburgh, Pa.

First patents filed in the United States for transformers having a closed iron core were as follows: 352,105, May 7, 1885, Zipernowsky, Déri, Bláthy; 349,612, November 23, 1885, W. Stanley, Jr., Great Barrington, Mass; 342,553, Feb. 26, 1886, Westinghouse; 351,589, March 6, 1886, L. Gaulard and J. D. Gibbs, of England; and 360,198, October 11, 1886, Bláthy.

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Inductors Biased with Permanent Magnets

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ASSOCIATE MEMBER AIEE

IT HAS LONG been known that when a highly unsymmetrical ($I_{min} \neq I_{max}$) current magnetizes a closed iron core in an inductor or transformer, the optimum design includes an air gap in the core to reduce saturation. The presence of the air gap has two opposing effects: (1) it increases the reluctance of the core to both the biasing (d-c) magnetization and the incremental (a-c) magnetization, and (2) the shift of magnetic operating point due to (1) reduces the reluctance of the iron to the incremental magnetization. If a permanent-magnet slab is used as a counterbiasing means instead of an air gap, the magnetic operating point may be shifted toward the maximum incremental permeability point with a gap much shorter than the optimum air gap. The direct increase in reluctance is then much smaller than in the air-gap case, and the inductance is much larger. A given core size can supply a larger inductance or, conversely, a smaller permanent-magnet-gapped core can supply the same inductance as a larger air-gapped core.

Because of the thin gaps involved, it is not practical to laminate metal permanent magnets to form the gaps. If they were not laminated, eddy currents would nullify the advantages. The advent of barium ferrite, a high-resistivity permanent magnet, has made such counterbiasing gaps practical. Such material can be inserted as thin slabs in gaps in ceramic or laminated metallic cores, or it can be formed directly as thin layers within ceramic cores.

The problem is that of designing electrical inductors each consisting of a ferromagnetic core interlinking a coil of wire. It is desirable that a method of design proceed from the specified electrical characteristics directly to the physical dimensions of the inductor without the use of trial-and-error methods.

The results are a series of design charts, one of which is shown in Fig. 1. The abscissa n_{1r} is calculated from the relation

$$n_{1r} = R_c^3 I_m / L$$

The values of g_{1r}, β, and B_m are read from the charts. The effective core length is

$$l_i = g_{1r}\sqrt{L/R_c}$$

The gap length is βl_i, and the rest of the design can be completed by appropriate equations. Means are provided for designing to thermal limits and for considering both copper and iron losses.

The use of permanent-magnet gaps permits reduction of the volume and weight up to 78 per cent below the corresponding values for air-gapped inductors, depending upon the particular specifications.

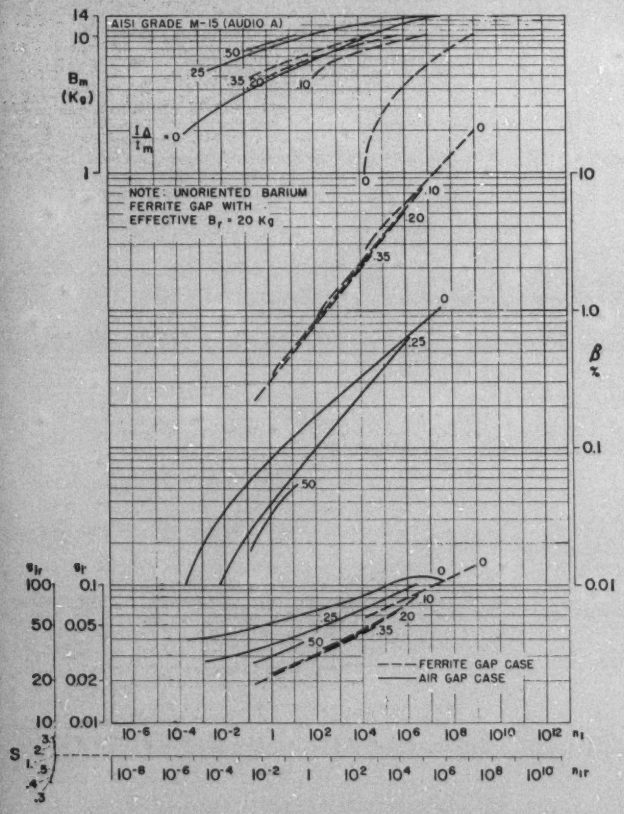

Fig. 1. Copper resistance limited designs; audio A steel.

Digest of papers 60-198 and 60-199, recommended by the AIEE Basic Sciences Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 31-Feb. 5, 1960. Published in AIEE *Communication and Electronics*, July 1960, pp. 273-91.

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Science, Technology, and the Training of Engineers for the World of Tomorrow

PHILIP SPORN
FELLOW AIEE

The problems, responsibilities, and achievements of both science and technology are discussed in an effort to dispel some widespread misconceptions concerning the role of each. Both are important and each derives expanded scope and significance from the other.

I SHOULD LIKE to use this occasion to discuss the role of science and technology in our society and the related problem of training engineers for the world of tomorrow.

The subject is not new; it has stirred controversial discussion for many years. However, it has recently come into sharper focus and become more critical because of the rapidly increasing importance of science and technology in our modern society and because of the change in their political, social, and economic context. At the same time, the distinction has become increasingly blurred by the progressively closer interrelationship that has developed between them in recent years.

For perhaps too long a time basic scientific research was, if not neglected, at least de-emphasized, but we now appear to be in danger of overcorrection. The pendulum threatens to swing too far toward science to the detriment of engineering and technology. The idea has become widespread that we must look almost exclusively to science if our society is to continue to progress—that engineering is a minor detail to be easily resolved once the scientist has completed his work.

I do not know what foundation there can be for the notion that science is today more important and perhaps much more important than technology.

The fact is that there has been no revolutionary change in the relationship between science and technology. It has been a fruitful relationship going back as much as 100 years. The development from Faraday's scientific experimentation to modern electric power technology is one of its earliest, and perhaps the best, exemplifications.

Science and technology are both important, and each derives expanded scope, meaning, and significance from the other. Science may be said to represent an evolving body of systematic, experimentally verifiable knowledge regarding the relationships among the complex phenomena of the physical world. Scientists are concerned with improving man's understanding of his physical world and expanding the range of physical phenomena embraced by man's understanding. The engineer or technologist, utilizing the knowledge made available by the scientist, develops the means for controlling man's physical environment and transforming the conditions of life. The scientist usually works—but very seldom under the pressure of a timetable—in a field of his special interest, in which he has generally chosen to stake out a narrow sector for his own specialization. The engineer, on the other hand, while also operating within the area of his own competence, has to tackle a variety of problems, some of which may be new to him but to which he has to apply his scientifically based knowledge and skill and produce workable and economically practical solutions involving both analysis and synthesis, and generally within a rigid time limit. This is technology and engineering.

In their simplest concept, technology and engineering are applied science. But technology is, I believe, really a great deal more than this. It embraces all human experience with science, tools, methods, systems, and organization that add leverage to man's effort and make possible much greater abundance than his unaided physical strength and skill alone could deliver.

A MISUNDERSTANDING OF ROLES

DESPITE the close bond between science and technology, perhaps even because of it, there has developed a serious misunderstanding about the respective roles of science and technology that persists at almost all levels

Essentially full text of an address presented on the occasion of the conferment of an Honorary Doctorate Degree by Technion, Israel Institute of Technology at a special convocation held at the Carnegie Endowment International Center, New York, N. Y., March 8, 1961.

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of our society. It has had an important impact on education and educational programs and could have a severe, adverse effect on our ability to cope with the difficult problems confronting our society and our future as a nation; it could adversely influence our security and our defense, and the defense and survival perhaps of the whole West.

This misunderstanding has become pervasive throughout our whole society, among laymen, high school students, faculty and counselors, technical-college students and faculty, and even among the scientists themselves.

Even such a distinguished student and analyst of science and scientists as Sir Charles P. Snow ascribes to scientists the exclusive possession of powers and skills which they simply do not possess. When Sir Charles says he wants "scientists active in all the levels of government" because they are trained in foresight, or that "scientists have it within them to know what a future-directed society feels like," or again that scientists "have been in certain respects just perceptibly more morally admirable than most other groups of intelligent men," he is ascribing qualities to scientists that are either totally absent in many cases or, if they exist, certainly do so to no greater degree than among other members of our society. And this type of glorification of the scientist, with the accompanying, if subtle, downgrading of the engineer, has resulted, I believe, in a great deal of damage.

It may be added that the scientists are not the only ones who have made claims for science that would be difficult to demonstrate. When the scholarly president of one of our great midwestern universities says he believes "that science today has the magnificent power of creating conditions that will allow man, for the first time in recorded history, to master the created universe in such a way that human dignity can rise above the miserable conditions that reduce man to little better than an animal," he is claiming for science more than it can achieve alone.

The confusion over the distinction between science and technology and the concept of the scientist that ascribes to him these many attractive qualities have resulted in a tendency in recent years to disparage engineering, thus affecting the choice of careers by a significant portion of our high school population. This has resulted in a decline in enrollment for engineering training in many of our schools, with an accompanying rise in enrollment in scientific training. Based as it is, in all too many cases, on the misconception just described, this swing from engineering to science is cause for concern.

It is cause for concern because, if the present trend to elevate the importance of science at the expense of proper emphasis on engineering continues, our rapid rate of technological development may be seriously impaired.

I can do no better, to point up clearly and strongly both the importance of recognizing the indispensable role of engineering in bringing into fruitful use some of the most advanced scientific discoveries of our times, and the damage in retarding such useful applications of scientific ideas, both old and new, than to cite and discuss three currently exciting technological developments, in general erroneously thought to require additional efforts of science rather than of engineering: One of these is in an advanced stage of development; the second is moderately advanced; and the third in a very early stage.

ATOMIC ENERGY

LET US CONSIDER first atomic energy. Early in the development of the fundamental scientific principles of nuclear fission, many of our scientists recognized that its major peacetime application was going to be in the field of electric power generation. Many of those who made such significant contributions to the Manhattan District Project continued their work in atomic energy after Hiroshima and the end of the war. It was their scientists' viewpoint that dominated the early postwar development of atomic power generation. The result was a misdirection of effort and an induction of false hopes because of the failure to appreciate the problems of technological, as distinguished from scientific, development. The scientific basis for the nuclear generation of electric energy was fully, or at least adequately, known, but the difficulties to be overcome in the engineering implementation of the known scientific principles were overlooked. In particular, the engineering economic factors were not properly evaluated, and it was not adequately understood that the conventional fuel technology, which it was hoped would be displaced with nuclear-fuel-based atomic technology, was in a phase of dynamic change and progress which presented a moving target, so to speak. Even more, there was a failure to recognize that, in its essentials, progress in nuclear power technology could best be obtained by building upon the existing and highly advanced power technology.

Some, but not all, of these errors have now been rectified and the fact that we are today quite well advanced along the road of making atomic energy competitive in the high-cost energy areas of the United States is due in large measure to the fact that, for the last decade at least, we have been concentrating on the engineering aspects of atomic energy generating designs rather than on the scientific aspects. Costs, questions of arrangement, questions of size, the problems of heat transfer, the problems of pressure suppression in case of rupture of a vessel under pressure, the problems of metallurgy both within and without the reactor, and the problems of thermodynamic heat balance all are now being given the consideration they require.

The early hope of the scientific community for some startling breakthroughs in the development of atomic energy has been abandoned. If we have not yet reached the goal of competitive atomic energy, it is not because the underlying scientific principles are not understood, but because of the difficulties encountered in solving the many complex engineering and economic problems.

Much time was lost, however, before it was recognized from which partner of the science–technology team the real contribution was needed.

SEA WATER CONVERSION

Consider now the case of sea water conversion, a problem particularly acute in Israel but also not an insignificant problem already in some parts of the United States. Although the problem is not solved yet, we are well on the way to reaching a solution. The considerable progress that has been made in recent years is due to the advances in technology and to engineering improvements.

The basic science of getting the salt out of sea water is as old as recorded history. Julius Caesar and the ancient Phoenicians had already found the secret—just distill the waters of the sea. However, the economic application of the simple fundamental principle to replace or augment natural water resources is a totally different affair. To bring this about, quite a few engineering problems and difficulties had to be solved and overcome.

Fortunately, we have already made great strides in resolving many of these problems: in applying lower-cost materials to improved designs; in advancing the terminal temperatures of operation; in reducing scale and corrosion; and in seeking lower-cost sources of energy either through independent approaches or through integration with other more advanced technologies, such as power generation. This progress has been achieved only during the past decade or so, when necessity once more became mother to invention—engineering invention. Through the development of multistage flash evaporators we have seen the utilization of heat energy increased tenfold and more, with costs so materially reduced that in a yet small but increasing measure, converted water is already competing with the ever more costly natural supplies.

I believe that the time scale for broader application of water conversion to meet the needs of society will be reduced not by any spectacular scientific breakthrough or innovation, but rather by the development and application of continued small advances in chemical and thermodynamic engineering.

MAGNETOHYDRODYNAMICS

Engineering solutions also are required to put to useful service of society long-known and well-understood scientific principles in the intriguing field of magnetohydrodynamics.

More than 100 years ago, Michael Faraday demonstrated that if a conductor moves through a magnetic field, current is caused to flow in the conductor circuit. Faraday experimented with copper conductors such as we use in our motors and generators today, but he also investigated a moving fluid, namely the River Thames, as a conductor moving through the earth's magnetic field. Because of poor conductivity of the water and the weak magnetic field, no current flow was recorded in the Thames. But nonetheless, Faraday had conceived the magnetohydrodynamic (MHD) generator. Later innovators tried MHD generators, but they failed because of inadequate scientific knowledge of the magnetic fields required and conductivity of fluids utilized.

Recent work in our space program has provided us with the necessary scientific understanding of the conductivity of gases at high temperatures so that now we can describe, theoretically but accurately, the performance of an MHD generator, in which gases raised to very high temperatures (so that they behave as reasonably good conductors) pass through a strong magnetic field and generate electric energy directly from the heat in the gas. Because of the very high temperature at which it operates, the MHD generator gives promise of very high thermal efficiency and, therefore, low fuel cost; and because it eliminates the need to convert heat energy first into mechanical energy, in going from heat to electricity, it offers great promise of reduced equipment and, therefore, reduced capital cost.

The phenomena involved in an MHD generator are understood. Its theoretical equations have been fully confirmed by experimental generators, one of which has just recently generated as much as 185 kw for short periods of time. Engineering problems must now be attacked and solved. High-strength and economical magnetic fields must be designed. This has required the introduction of the scientifically demonstrated but far-from-engineered concepts of cryogenics and superconductivity. Walls must be designed to contain gases at temperatures of 5,000 F or higher. Even though present engineering practice has not been called upon to contain gases in boilers above 3,500 F, there is every reason to believe that sound development based on today's engineering practice can lead to designs that will serve at 5,000 F.

In each of these three very exciting and potentially very important scientific technological developments, engineering is the critical component in determining the time and extent of social–economic significance.

EDUCATION

In the face of a developing need for more and better-trained engineers, so well exemplified by the three technological developments just discussed, our educational institutions have been conscientiously striving to meet their responsibilities. Generally they have been increasing their emphasis on mathematics and on science. In many cases they have been allotting some time to the humanities. Whether realistically evaluated or not, however, they have in too many cases considered they were almost completely bound by historical and rigid precedent as to student time availability. The tradition of graduating a salable product in a particular engineering specialty, and within a limited time, is a strong one. The net effect of this has been, on the whole, a sharpening or narrowing of the field of vision of many of our graduating engineers.

Is it not pertinent, then, to ask how well equipped are the products of such training to solve the engineering problems of the world of tomorrow?

The answer depends on the kind of engineers we want. If what we are looking for in engineering are people who can solve a particular problem from a specialized, rather narrow viewpoint, then the kind of curricula we have in many of our engineering schools and the faculties we have to implement these curricula are all good. But if we are looking for people who can take an integrated view of a problem and can place it in its broad social, political, and economic as well as technical context, if we want people who start out with an integrated view of the world and what engineers can do in and for it, then it seems to me that the situation with regard to the adequacy of curricula and of faculty is, in most cases, not so good.

There are altogether too few places where engineering students are given an opportunity to acquire a firm background in the liberal arts—in history, the history of science and technology, in economics, and political economy, the dynamics of political and social–economic history, and in philosophical and cultural values. Nor are there many places where the attempt is made even to stimulate at least the awareness among engineering students of the importance of integrating these materials into their career activities. The world we are in, and in which the engineer must make his place, is literally changing before our eyes. Yet I personally have not found—either among students, with whom I have considerable contact, or among practicing engineers—anywhere near enough literacy in these particular fields to permit the breadth of view for an over-all synthesis approach.

We simply do not get enough people out of our engineering schools who are able to visualize the larger systems within which the narrow solutions must fit, who can see things in scale and can completely visualize the significance of large industrial complexes at a single location. The conceptualization of a vast aggregation of highly complex machinery and how it relates to the social–economic and even historical scheme of things is almost utterly beyond them.

The engineer ultimately is not going to be judged by whether the machinery he has had a hand in designing rotates at a constant speed or a variable speed, or whether the temperatures of his metals are at 1,100, 1,200 or 1,300 F, or whether his unit stresses are 20, 50, or 100,000 pounds per square inch. The judgment of society will be based on how the complex he creates functions in society, and what it does for society. By these standards our current engineering education is, by and large, deficient.

But I do not believe it is necessary to despair about it. I believe there are a great many things we can do.

SUGGESTED REMEDIES

First, there is a great need, I think, for our colleges to comprehend the idea that the 1960-65 student body will not make the world of 1965 but will have the responsibility for creating the world of 1985. It is for this that they must be trained. We need always to remember that. I know how difficult it is to do long-distance crystal gazing, but unless you do that you cannot do the job of planning the education of these people properly. The colleges and universities not only must never surrender their responsibilities or their historic tradition of being leaders of thought, but also must ever remember that they are educating men who will be leaders in thought.

There is something, too, we could do about the student body entering our engineering schools. I believe all our engineering schools are weak because of the inadequacy of the student body. We just do not get a large enough share of our talented youth. I believe we must find some way to attract more of our young people into engineering schools, and we need to do a great deal of what I can best describe as "beneficiation" before we bring this talent into our engineering schools. Essentially, I believe, this requires a reorientation of both the character and the tempo of training in our high schools and preparatory schools. I think a great deal can be done in this regard, and we have to find ways to do this work. We need to do a better job of finding and selecting the material that results from that beneficiation.

The curricula that we establish for the people we bring into our schools—I won't say this has to be universal, but it is certainly true for a significant percentage of the group—need to be deepened and broadened. Their training must include a great many subjects we now hardly touch upon in our technical and engineering schools. The student needs to be given at least a start toward understanding the world he is going to work in, the world he will try to improve, and the world he may have the job of running. He needs to have solid background in order to have full awareness not only of all the aspects of the big technological problems he is working on and trying to solve, but of how they tie in with attempts by others to produce a better social and material environment. In short, since he is going to be called upon to reach decisions that may have far-reaching effects on society, not only must he be capable of crossing traditional dividing lines in engineering, but he must develop a deep understanding of the social–economic forces at work in our own country and in the world.

SPECIALIZATION AND SYNTHESIS

We need to do some clear thinking about specialization. Specialists are needed, but the specialized skills can be developed much more easily at a later period than can the breadth and depth. These latter must come earlier. No engineer, for example, should be permitted to go out into the world without fairly solid grounding in geography and oceanography; or in meteorology, geology, and hydrology. And surely he cannot do without a knowledge of engineering materials, structural chemistry, or energy sources and energy conversion systems. We need to look at the problem of engineering training in terms of a time period that extends well beyond the demands of the moment for certain highly specialized skills.

I also believe we need to do a great deal more work on synthesis and in the development of skills in synthesis; that is, the development of diverse elements into complex systems. We need to develop carefully the people who have some initial abilities in that direction and then strengthen and improve their skills.

I believe the students in our engineering schools, if they are going to be engineers and not merely highly successful, even brilliant, technicians, need to have a great deal of contact with engineering. They need to have much greater contact with industry. I myself, in our own company and in other ways, have had a great deal of contact with a number of the co-operative programs operated by our engineering colleges, but I do not believe these programs are widespread enough. We need more of them. They bring students into contact with engineers at an early phase of their careers, and this is to the good. It gives them a much more solidly based appreciation of engineering and of a career in engineering.

I think we need to do something about faculties. I believe students of engineering need to be inspired to climb to the heights of engineering. If they are going to be great engineers, they ought to be exposed to at least a few great engineers. Certainly many of our great surgeons are people who were inspired by studying under the guidance of great surgeons. We do not have that, at least we do not have enough of it, in our schools of engineering. I believe this can be rectified by bringing some practicing engineers into our engineering faculties. There is a good technique for this—the adjunct professorship—which should be developed.

The other side to this is the benefit derived by the practicing engineers from that contact. Engineers who practice engineering, who visualize, project, develop, and eventually see great engineering conceptions become work in progress, can benefit by communicating some of their ideas to engineers in the making.

CONCLUSION

WELL, this is quite a list of things we need to do. I believe they can be done. If we do succeed in accomplishing all these things, then we will have trained and produced the engineers we must have in our society in order to solve the terrifically difficult national and world problems confronting us today and which will confront us to an even greater degree tomorrow.

Technology founded on scientific knowledge has made possible the present Western civilization with its high level of material welfare and the total elimination of slave labor. Plato could not envisage a republic without slaves. Our modern technology and our social organization founded on that technology have the unique capacity to create material benefits in abundance for the population as a whole. Through science and technology we have learned how to provide a new scale of well-being in the material things of life while continually lessening the component of human labor necessary to produce these material goods. Only by maintaining a proper balance between science and engineering can this progress be continued. With material needs provided for, we may then hope that man may, as never before, be able to devote his energy increasingly to the spiritual enrichment of his life.

Computer for Nuclear Research Center

The Stretch, IBM's powerful new computer, will be used in one of the nation's key nuclear research centers —Los Alamos Scientific Laboratory in New Mexico. The system will be put to work on the complex and critical projects for which the laboratory has become a focal point in the free world: research and development in nuclear and thermonuclear energy. The laboratory is operated by the University of California for the U. S. Atomic Energy Commission.

At the laboratory, Stretch will aid scientists in critically important research in nuclear and thermonuclear energy. The computer's speed—it is capable, for example, of performing more than 30 billion multiplications in a 24-hour period—makes possible solutions to problems for which equations are known, but which have been too large or complex for economical or timely solution in the past.

From the operator's console *(foreground)*, the system can be controlled and monitored. The central processing unit *(right background)* is the heart of the computer. At left is the exchange, which provides a new peak of efficiency in handling input–output devices and is able to control a peak flow of 800,000 characters of information per second.

Telemetering in the Crude Oil and Crude Oil Products Pipeline Industry

I. B. CLOESSNER, JR.

From modest attempts to transmit data over short distances, telemetering systems in the pipeline industry have been developed which can transmit practically any variable to any desired point. Although present systems are highly sophisticated, many problems remain to be solved. A review of pipeline systems from early beginnings should help clarify these problems.

AT the present time, telemetering, as an element of automation, enjoys a prominent position in the pipeline industry. It has made supervisory control of pipeline systems a reality. Through the use of telemetering as a part of supervisory control, a few men located at key points can monitor and control a vast network of pipeline systems.

The dispatcher can obtain data from virtually any point in a system by the operation of a push button or dial. In more sophisticated systems, automatic data logging is employed; thus, he needs only to observe the log sheet to obtain the information desired. Information which was formerly relayed to him by telephone is now at his fingertips.

These developments, however, have not come overnight. The evolution of telemetering equipment for pipeline use has been a slow, painstaking process.

In the telemetering industry, as in other industries, the recognition of a definite need prompts a solution to a problem. The first solution may not be the complete answer, but nevertheless, it is a starting point. From these early attempts come the refined, tried, and proven solutions. Thus, new devices or procedures become accepted tools of industry. This, however, is only the beginning. As new problems arise and new tools are developed, more experience is gained and previously developed tools are refined. As these new tools are developed and older tools are refined, new demands are made for more tools. These demands, however, are not so easily satisfied. Specifications become more rigid. The increase in the use of tools has also brought about a maintenance problem. Reliability, ease of maintenance, standardization, and flexibility become major requirements. Thus, from meager beginnings, whole systems are developed, which may be expanded to provide the solution to virtually any problem which may arise.

Essentially full text of paper 61-16, presented at the AIEE Winter General Meeting, New York, N. Y., Jan. 29-Feb. 3, 1961.

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PIPELINE SYSTEMS

The Crude Oil System. The crude system is made up of two basic components; i.e., gathering lines and trunk lines. A typical system is shown in Fig. 1.

In the oil field the crude is pumped or delivered from the well to a producer's tank. The producer's tank in turn, is generally connected to a main trunk line system by a gathering line. At the producer's tank a field gauger checks the crude to determine its gravity and basic sediment and water (BS&W) content. If it meets pipeline requirements for BS&W content, an opening gauge reading is taken and it is then pumped or allowed to flow through the gathering line to a trunk line station tank. In many cases today, the positive displacement (P.D.) meter has replaced the tank gauge for measuring oil.

The tank gauge or P.D. meter reading is extremely important at this point, since the pipeline company, acting as a common carrier, assumes the responsibility of delivering the amount of oil received (excluding any pipeline allowance) as indicated by the gauge or meter readings.

The trunk line system is merely a main artery through which the crude is pumped from the gathering line to its destination, which may be either an interconnecting carrier, a marine terminal, or a refinery.

Along the trunk line system intermediate booster stations are installed to permit increased capacity of the line. In addition, at several points along the line, injection stations pump crude from other fields into the passing stream. Thus, a single trunk line may be called on to deliver several grades of crude.

The Products System. The makeup of the products system is just the reverse of the crude oil system. The products generally originate with a refinery, a marine terminal, or an interconnecting carrier and are pumped through the main or trunk line to delivery points along the way. At each delivery point the specific product desired is drawn from the line. Each draw point may be either local tanks or a pipeline. Thus, the products system begins as a single trunk and expands out in a manner similar to limbs on a tree.

Development. The first crude oil pipelines were constructed in the latter part of the 19th century. In the early part of the 20th century and especially in the 1920's a large number of pipeline systems were built. Expansion continued in the 1930's at a reduced rate until the beginning of World War II, when construction virtually came to an end.

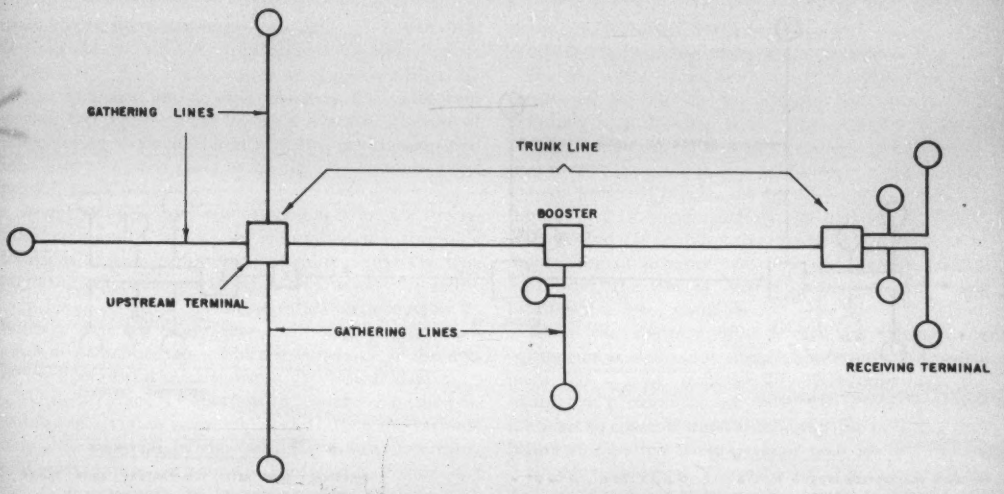


Fig. 1. Block diagram of a simple crude system.

The design of these systems was simple. A single, long pipeline was actually made up of several short pipelines operating independently. In each leg of the line, oil was pumped from the preceding station into tanks at the next station. Thus, it was pumped from tank to tank until its destination was reached. A simple system of this type is shown in Fig. 2. At each station along the line, reciprocating pumps were driven by Diesel engines. Fuel was taken directly from the pipe lines. Since automation was practically unknown, all operations were manual.

With the coming of World War II, these systems were subjected to demands, which caused a literal bursting of the seams. In order to increase throughput, additional pumping units were installed and pressures were increased. In cases where pressures could not be increased, lines were looped.

During the war, the over-all economy of the nation rose to a level much higher than that of prewar years. Thus, at the close of the war, with the lifting of gas rationing, the demand for crude oil and crude oil products continued. These prewar systems were still being subjected to extreme demands. In addition, operating costs were increasing and profits were decreasing. It was obvious to leaders in the pipeline industry that steps must be taken to meet postwar demands and to cut operating expenses. New technological approaches to pipeline design were investigated and modernization programs were inaugurated. Telemetering played an important part in these early modernization programs.

EARLY USES OF TELEMETERING

One of the most obvious ways to reduce operating costs in any industry is to reduce the number of operating personnel. Thus, pipeline management investigated the various ways in which the personnel requirements could be reduced. Some methods involved the complete rebuilding of systems. Other methods involved building of new systems to replace old systems. These were all long term proposals and offered no immediate relief. The only solution remaining involved the use of instrumentation to replace men.

The development of the selsyn and potentiometer types of remote-reading tank gauges permitted an immediate reduction in operating personnel at practically every pump station. The use of analog-pressure and flow-rate telemetering from remote injection stations permitted a closer observation of pipeline conditions. Leaks were spotted more quickly, reducing oil losses. Efficiency of the pipeline operation was improved.

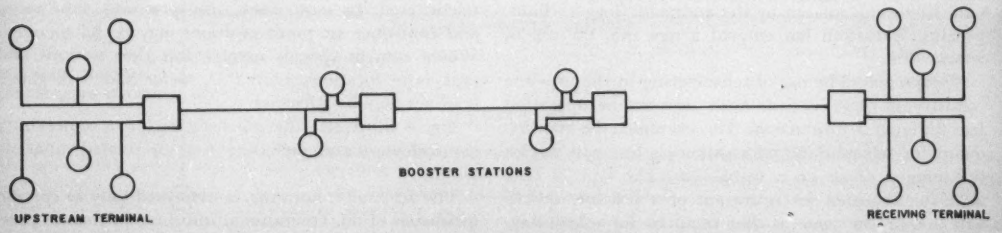


Fig. 2. Early crude systems.

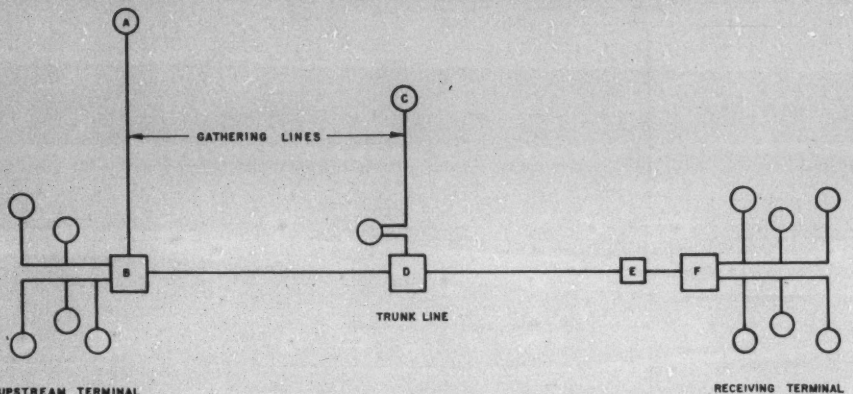

A
C
GATHERING LINES
B
D
E
F
TRUNK LINE
UPSTREAM TERMINAL
RECEIVING TERMINAL
OUTSIDE PLANT TELEMETERING
PRESSURE AND/OR FLOW RATE — A TO B, C TO D, F TO B, D TO B
TANK GAUGE P. D. METER — A TO B, C TO D
BS & W CONTENT — A TO B, C TO D
GRAVITY OR INTERFACE — E TO F
FLOW CONTROLLER SET POINT — F TO B, D TO B
IN PLANT TELEMETERING
PRESSURE, FLOW RATE, TEMPERATURE, TANK GAUGE,
P. D. METER, GRAVITY, OR INTERFACE, FLOW
CONTROLLER SET POINT — ALL AT LOCATIONS D, B & F

Fig. 3. Present-day telemetering in crude systems.

As the demand for telemetering increased, new developments were made. The introduction of the digital tank gauge permitted, on a small scale, partially attended operation of injection stations, which previously had been fully attended.

While the use of telemetering continued to grow, other phases of pipeline operation were being improved. New lines were being constructed. Old systems were being modernized. Automation was invading the industry. Thus, the evolution of the pipeline industry was well under way.

TELEMETERING IN PRESENT-DAY PIPELINES

General. Pipeline systems of today resemble their predecessors only in purpose. Modern centrifugal pumps have replaced reciprocating pumps. Electric motors have replaced Diesel engines. Manual operations have been replaced by pushbutton operations. In many instances, pushbuttons have been extended for hundreds of miles through the use of supervisory control. The eyes of the operators have been extended for hundreds of miles by telemetering. Manual writing of pertinent data has been replaced by the automatic logger. Thus, pipeline operation has entered a new era—the era of automation.

Application. The use of telemetering in the pipeline industry is quite varied. Each segment of operation has different requirements. For example, the requirements for telemetering on a gathering line will not be the same as those on a trunk line. The type of telemetering required for operation of a pipeline system will not be the same as that required for scheduling. Fig. 3 illustrates the present-day use of telemetering on a crude system. While the operation of a products system is different from that of a crude system, the use of telemetering on both systems is quite similar.

From Fig. 3 the following variables involved in pipeline telemetering can be obtained: (1) tank gauge readings, (2) P.D. meter readings, (3) gravity in degrees A.P.I., (4) pressures, (5) flow rates, (6) temperatures, (7) BS&W content, and (8) pressure or flow controller set point.

A few other variables may be telemetered; however, they represent a minority.

From an operational standpoint, all of the listed variables may be needed. The operator requires pressure and flow rate telemetering in order to monitor the pulse of the system. He requires tank gauge and P.D. meter readings in order to insure the delivery of the correct amounts of specific grades of crude. Gravity is telemetered from a few points, a few miles upstream on an incoming line, to give advance warning of an approaching interface.

When telemetering is used as an element of supervisory control, generally only a few variables will be telemetered. In most cases, only pressures, flow rates, and controller set point positions may be telemetered. Where control systems involve injection stations and tank farm locations, both P.D. meter and tank gauge readings may be telemetered.

Fig. 4 illustrates the telemetering on a supervisory controlled system, including that of related adjacent systems.

The scheduler, however, is interested only in specific quantities of oil. Operational information such as pressures or flow rates are of little value to him. Only in

cases where the scheduler is required to control field stations directly does he need operational data.

Generally, P.D. meter and tank gauge readings, interface locations, and in some instances, flow rates from certain key pipelines, are his main concern. The use of telemetering to provide him with this information permits him to devote more of his time to scheduling the movement of oil.

Requirements. Since telemetering is being used to replace man and in many cases is installed at inaccessible locations, it must fulfill certain requirements. The telemetering equipment must be at least as reliable as the man being replaced. It will be called on to operate 24 hours a day, for many years, with only a minimum amount of maintenance. Since it functions as the eyes of the operator, it must transmit dependable data.

While accuracy is important in telemetering, the percentage of accuracy required depends upon the variable being telemetered. In the case of pressure, flow rates, and temperature, present-day equipment provides the necessary accuracy. In the telemetering of these variables, however, repeatability is of prime importance. If tank gauge and P.D. meter readings are being telemetered, absolute accuracy is required.

While present-day equipment is capable of transmitting gravity and BS&W content fairly accurately, some improvement is indicated, particularly in the transmission of gravity.

Cost of equipment is important; however, it is not generally the deciding factor in the selection of telemetering equipment. The most economical equipment is not always a bargain. Reliable, maintenance-free operation is primarily the deciding factor. If telemetering equipment is to be used to monitor hundreds of thousands of dollars worth of equipment, the extra expenditure for reliable equipment is money well spent.

On the other hand, however, when telemetering is considered for use on low revenue systems, cost can definitely be a deciding factor. For example, it would be highly desirable to remotely control a gathering station so that the services of a field gauger could be eliminated. This will require the highly accurate telemetering of (1) P.D. meter readings, (2) gravity, (3) BS&W content, and (4) temperature, in addition to the present monitoring of pressure and flow rate. Under present conditions, the cost of such a system would be prohibitive if it were available.

Thus, the engineer who selects the telemetering equipment as well as the companion automation equipment has a great responsibility. Not only must the equipment perform its task today, but it must continue for years to come. It must also be capable of fitting into future automation systems.

Analog vs. Digital Telemetering. The pipe line industry today is torn between two philosophies in telemetering. On the one hand, proponents of analog telemetering maintain that nothing can take the place of a chart recording. They further maintain that trends may be observed, a problem may be analyzed and corrective action can be initiated more easily, if analog telemetering is used as a watchdog.

Advocates of digital telemetering argue that analog telemetering is not nearly as accurate as digital, particularly in transmission over great distances. They further maintain that trends can be observed if deviation detection and upset monitoring are incorporated into the digital system.

While both arguments have merit, all agree that

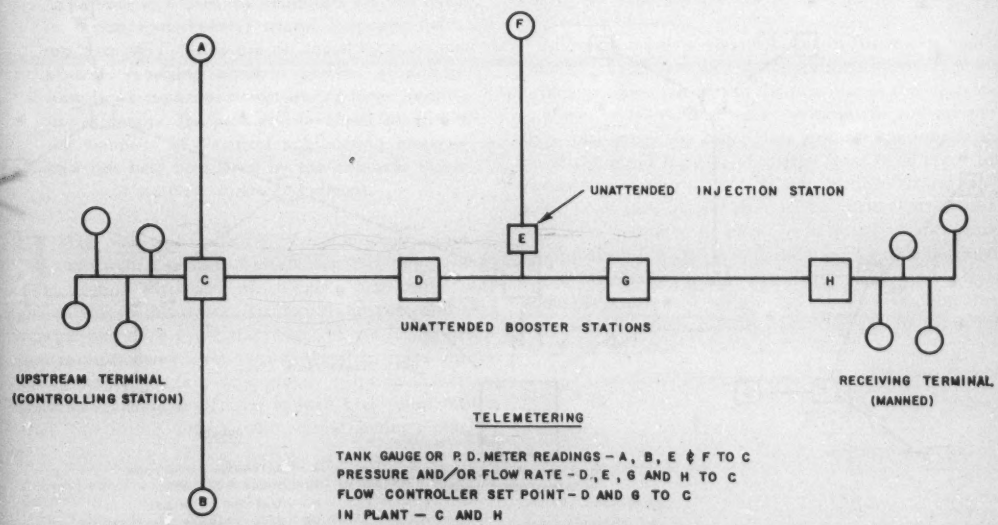


Fig. 4. Telemetering on a supervisory controlled system.

digital telemetering lends itself readily to automatic data logging and computer operation of pipeline systems. In addition, digital telemetering more economically utilizes communications facilities.

In the pipeline industry today, both types are being used, both with supervisory control and for monitoring purposes.

The use of digital telemetering with supervisory control has lagged for several reasons. First, until recently the selection of analog-to-digital converters has been limited and rather costly. Second, most analog-to-digital converters were electromechanical devices, which required considerable maintenance. Third, since few manufacturers could provide instrumentation for all telemetered variables, two or more digital code systems were encountered. This incompatibility of codes resulted in duplication of equipment and higher costs. This problem still exists, particularly when the transmission of tank gauge readings is involved. One solution would involve the changing of tank measurements to decimal divisions such as feet, tenths of feet, and hundreds of feet. Since tanks are generally gauged to the nearest one-eighth of an inch, or one ninety-sixth of a foot, a change to decimal divisions would increase resolution. Such a change would certainly be revolutionary in the pipeline industry, but would solve one of its instrumentation problems.

The introduction of solid-state electronic equipment into the control and telemetering industry may in time aid in solving a number of the problems associated with digital telemtering. If reliable, maintenance-free electronic equipment can be developed economically, digital telemetering will probably become more widely used.

There are exceptions, however, such as locations where only one pressure reading is desired, where analog telemetering will continue to be used for some time to come. Economically, at the present time, digital telemetering cannot compete.

FUTURE TELEMETERING SYSTEMS

As automation continues in the pipeline industry, the use of telemetering will become more and more important. Computer control of pipeline systems will become a reality. Telemetering will help to close the loop to the computer. The pipeline operator will become a computer operator. A few central locations may control a multitude of systems. With these additional reliability factors placed on the telemetering equipment, specifications for telemetering equipment will become more rigid.

Supervisory control or possibly automatic control of gathering systems will become a reality. In order for this to occur, however, the P.D. meter telemetering system will require absolute accuracy. BS&W and gravity telemetering equipment will have to be considerably improved.

Some of the problems which now confront the dispatcher will be solved by the use of data-gathering systems. Such a system is illustrated in Fig. 5. At each data gathering point, information such as tank gauge readings, temperatures, gravity, and P.D. meter readings will be read and stored simultaneously at predetermined intervals each day. Then on a programmed basis, each data storage point will transmit all stored data to a central dispatching location. Thus the dispatcher will have, at his fingertips, all the data necessary for him to perform his task efficiently.

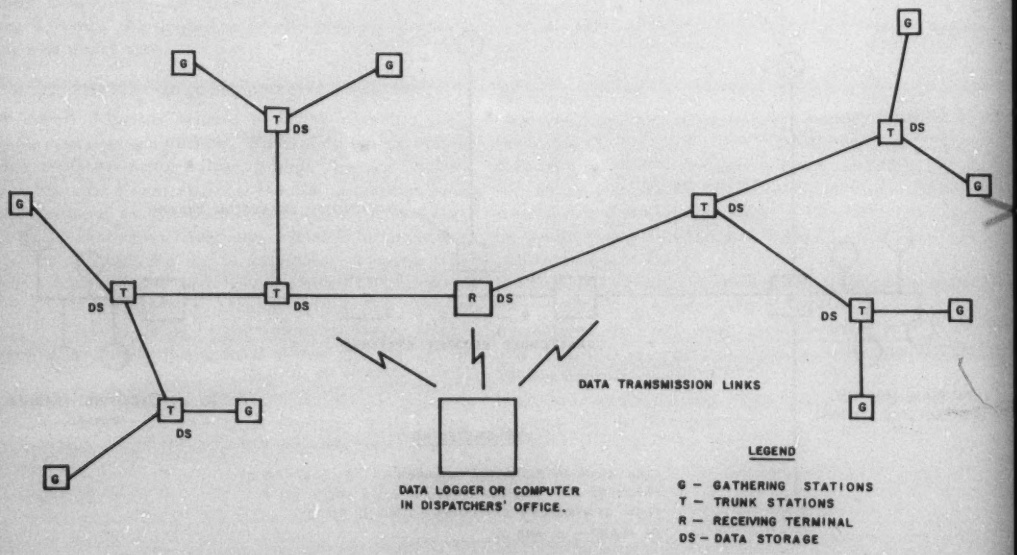


Fig. 5. Future data gathering systems.

While some of these ideas may seem like dreams, such dreams are required to stimulate new developments and improve old ones.

CONCLUSION

THE USE OF TELEMETERING has completely changed the methods of pipeline operation. Without it, many present day accomplishments would still be dreams of the future. Numerous problems have arisen and have been solved, while a number remain to be solved.

Telemetering equipment which is presently available for pipeline use, while adequate in many respects, leaves much to be desired. Special cables, which are not readily available or are costly, are required in some instances between primary transducers and amplifiers or analog-to-digital converters. There is very little standardization between different manufacturers with regard to transducer output signals or digital codes. In many instances, instruction books are inadequate. Some telemetering equipment is difficult to calibrate or will not hold its calibration. Since telemetering equipment may be installed in inaccessible locations, maintenance is definitely a problem. Any improvements in quality of telemetering equipment that reduces maintenance will be welcomed by the pipeline industry.

In the future, the pipeline industry will be making new demands for telemetering equipment. Different instruments will be required to aid in solving new problems. In order to avoid difficulties which now exist, joint efforts between the pipeline, instrumentation, and telemetering industries should be made in developing new equipment. If this is done, all the aspects of a problem will be made known, and all possible avenues can be explored in the search for the best solution.

Much has been accomplished by the telemetering and instrumentation industries in developing equipment for pipeline use. As a result, the pipeline industry today leans heavily on telemetering. Tomorrow, telemetering will be called on to carry an even heavier burden than it is carrying today.

Charging Large Capacitor Banks in Thermonuclear Research

H. K. JENNINGS

To contain and heat the deuterium plasma used in fusion experiments, strong magnetic fields are necessary. Fields are produced by a system of coils receiving a rapid transfer of energy from large capacitor banks storing large quantities of energy. The problems involved fall within the compass of electrical engineering analysis and can best be solved by the engineer in his normal work environment.

THE object of controlled thermonuclear or fusion research is to find a means for extracting energy from the hydrogen which exists in boundless supply in the earth's water. To do this in the form of a reactor one must cause the nuclei of the heavy hydrogen isotope, deuterium, to fuse together, releasing nuclear energy. The present approach is to heat deuterium plasmas (gaseous discharges) to such high temperatures that the fusing nuclei will release enough nuclear energy to keep themselves heated, thus causing the deuterium to burn.

Although many of the problems in fusion are highly theoretical and complex, the experiments provide many problems which fall within the province of the electrical engineer in his normal work environment and are perhaps best solved by him. Most fusion experiments involve the rapid transfer of energy from large capacitor banks to a system of coils which produce strong magnetic fields to heat and contain the deuterium plasma, and it is necessary to have great quantities of stored energy available. At present the most feasible means of achieving this goal is to charge large capacitor banks to some predetermined voltage and energy level, and then to discharge them rapidly into the gas by triggered

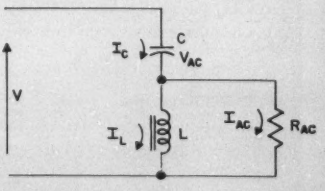


Fig. 1. Single-phase constant-current network.

A special article recommended for publication by the AIEE Nucleonics Committee.

H. K. Jennings is with the University of California, Los Alamos, Calif. The author extends his thanks to F. L. Ribe for his interest in this work and assistance with the manuscript.

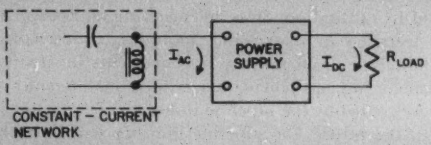


Fig. 2. Single-phase constant-current network with rectifier load.

switching devices such as ignitrons or spark gaps. Typical data for such an operation can be found in an experimental device known as Scylla at the Los Alamos Scientific Laboratory (LASL) which has an auxiliary capacitor energy storage bank with the following characteristics:

Stored energy	144,000 joules or watt-seconds
Voltage	20 kilovolts
Capacity	720 microfarads
Charging current	0.3 amperes
Charging time	48 seconds
Discharge current	750 kiloamperes
Discharge time	6 microseconds

Also at LASL an extremely high-energy capacitor bank known as the "Zeus" bank is under construction, with the following parameters:

Stored energy	6 megajoules or megawatt-seconds
Voltage	20 kilovolts
Capacity	29,400 microfarads
Charging current	14 amperes
Charging time	43 seconds
Discharge current	21 megamperes
Discharge time	200 microseconds

R-C CHARGING SYSTEMS

ENERGY STORAGE SYSTEMS with high charging currents, such as those described, make efficient charging systems necessary. The classical system involves the use of a power supply of constant voltage having a charging resistor R in series with a capacitor bank of capacity C. With this system the disadvantages are twofold: one must wait approximately 5 R-C, or 5 time constants, for the bank to be fully charged to a preset voltage, and there is a loss of power in the resistor which seriously reduces the system efficiency. In fact, the energy lost in the charging resistor is equal to the energy $\frac{1}{2}\ CV^2$ finally stored in the capacitor bank. This is easily shown by integrating the dissipated power for all charging times from zero to infinity. On large banks the power dissipated in the charging resistor can be considerable. For example, on the large LASL bank described, 6×10^6 watt-seconds of stored energy, with an equal amount of energy lost, represents 6×10^6 watt-seconds per 43 seconds, or 140 kw dissipated over the charging cycle.

IMPROVED CHARGING SYSTEMS

BETTER CHARGING SYSTEMS have been developed at LASL to avoid these disadvantages. One such system utilizes a linearly rising voltage which makes the use of resistors unnecessary. Since the charging current is given by $C\ dV/dt$, it will have a constant value I_c if the voltage is made a linear function of time:

$$V = \frac{I_c}{C}\, t. \tag{1}$$

The voltage on the capacitor divided by the constant current I_c thus represents an effective resistance given by

$$R_{eff} = t/C. \tag{2}$$

This resistance is directly proportional to t and inversely proportional to C. It starts at zero when the voltage on the bank is zero and rises linearly with time to some nominal value determined by the voltage and current rating of the power supply. As long as the voltage is brought up linearly there is an effective resistance proportional to this voltage and one does not need a dissipative current-limiting resistor in the circuit.

One can achieve the necessary condition of a linearly rising voltage by using a motor-driven continuously variable autotransformer, induction regulator, or saturable reactor with the control element programmed so as to produce a linearly rising a-c input voltage to a rectifier charging system.

SYSTEMS USING THE CONSTANT-CURRENT NETWORK

THE CONSTANT-CURRENT NETWORK,[1] known for many years, has proved to be an admirable device for the charging of large energy-storage capacitor banks. The single-phase circuit is shown in Fig. 1 and has the property that when L and C are in resonance the load current I_{AC} is independent of the load resistance R_{AC}. To show this we note by inspection of Fig. 1 that the voltage V_{AC} across R_{AC} and L is

$$V_{AC} = \frac{V\, j\, X_L\, R_{AC}}{X_C\, X_L - jR_{AC}\,(X_C - X_L)}, \tag{3}$$

where X_C and X_L are the reactances of C and L. The load current is V_{AC}/R_{AC}, and it will be independent of R_{AC} only if the second term in the denominator vanishes. The condition for constant current is therefore that $X_C = X_L = X$; i.e., that C and L be in resonance. The load current is then given by

$$I_{AC} = j\ V/X. \tag{4}$$

It is a function of V and X only, so that if the latter two

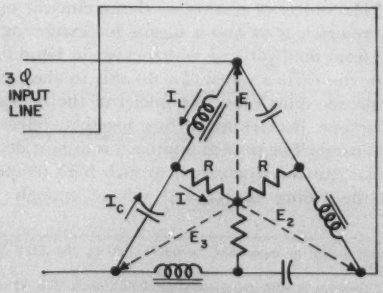


Fig. 3. 3-phase constant-current network.

parameters are fixed in the circuit the current is constant.

If this remarkable network is inserted in the primary of a d-c power supply the current i_{AC} is independent of load. In any power supply (Fig. 2) $i_{AC} = Ki_{DC}$, where K is a constant. If the alternating input current is made constant the direct output current will likewise be constant.

If, in Fig. 2, we replace R_{load} by a large capacity, such as an energy-storage bank, the charging current will remain constant. A physical explanation may be in order. As we saw earlier in equation 1, the voltage on the capacitor bank when it is charged at some constant current I_c is given by $V = I_c t/C$, where t/C is an effective variable resistance. At time $t = 0$ the resistance represented by the bank is zero and the bank voltage is zero. As time goes on the bank voltage rises linearly with time. The current at all times remains constant and may be considered a constant of proportionality between the increasing voltage and effective resistance. It should be borne in mind that this effective resistance, t/C, does not represent dissipated energy at the time the current is flowing; the current merely produces stored energy in the capacitor bank. The effective resistance is a resistance only in the sense that it is equal to the bank voltage divided by the charging current at any instant of time.

A more effective and usable constant-current network for large power systems is the 3-phase system shown in Fig. 3. The load current I is found to be

$$I = \frac{jE_1X_c - jE_3X_L}{X_LX_C + jR(X_C - X_L)}. \quad (5)$$

Again, at resonance $X_C = X_L = X$ and

$$I = \frac{j(E_1 - E_3)}{X}, \quad (6)$$

independent of load resistance R.

DESIGN PROCEDURE FOR CONSTANT-CURRENT NETWORK

DESIGN PROCEDURE for utilizing the constant-current network involves equation 4 or 6 for the single-phase or 3-phase cases respectively. These equations give the primary input alternating current to the power supply. Once the desired rectified charging current is determined one can obtain the alternating current required; this current depends on the type of power-supply current used. In equation 4, the single-phase case, X can be calculated once V and i_{AC} are specified; this gives the inductance L and capacitance C, inasmuch as $X = \omega L = 1/\omega C$.

In the 3-phase case, equation 6 can be put into more recognizable form. Let E be the magnitude of the line-to-line voltage; then

$$I = |E|/X. \quad (7)$$

Thus in either the 3-phase or single-phase case the required reactance X is determined by the line-to-line voltage and the alternating current desired.

A major advantage of the constant-current network is that it provides automatic short-circuit protection. If a capacitor is short-circuited, a condition which is quite likely in large banks with many capacitors in parallel, the design current is not exceeded and the power supply is protected.

A major disadvantage of the network is that, if the capacitor load is inadvertently disconnected from the supply during the charging cycle, the supply voltage can rise to many times rated voltage, producing serious damage to equipment. Quick-acting over-voltage relays must be provided to prevent this eventuality.

REFERENCE

1. Constant Current Sources, L. C. Green, J. B. Kuper, *Review of Scientific Instruments*, New York, N. Y., vol 11, p. 250, August 1940.

Satellite Moonlight Detector

A new light detecting device, called the "Moonlight Photodetector," which can aid in evaluating research data from an orbiting satellite, is under advanced development by IBM scientists at the company's new research center, Yorktown Heights, N.Y., supported by a contract with the Goddard Space Flight Center of the National Aeronautics and Space Administration. The device is the heart of a system that determines the direction in which the satellite's instruments are pointed. It is 10 times as sensitive as silicon solar cells and has a silicon surface smaller than a pinhead. It can detect very weak light rays from the moon and withstand intense direct sunlight and firing of the satellite vehicle into space. A 1.36-volt battery the size of a penny can operate it for several years.

Reliability in Missile and Space Operations

L. I. DAVIS

Three crucial factors in missile reliability are design, component quality and human error, with special emphasis on component quality. Success in our missile effort will not be achieved unless there are orders of magnitude improvement in parts reliability.

AT THE Air Force Missile Test Center (AFMTC), the executive agent of the U. S. Defense Department for the operation of the Atlantic Missile Range, we are not interested in the organization of discussions on reliability, we are interested in reliability itself. At the research and development test range, we are at the end of the road in the progression from planning to design, to fabrication, to preflight test, to launch. We are interested in results. Those that we have seen so far in development tests show we are climbing the reliability growth curve. We still have a ways to go to achieve the levels we need to put a human into orbit and return him safely. Unreliability can mean a very expensive missile and space program for this country.

To supply background, I will describe the Atlantic Missile Range and discuss the important role of component research and development; then attempt to prove my point by giving some abbreviated statistics on success and failure in our missile and space research and development programs.

Let us take a look at some quantitative measures of our progress in the struggle to achieve reliable missiles and space systems.

The Atlantic Missile Range was 10 years old this past year; in that decade almost a thousand missiles have been launched—from small weather rockets to huge ballistic "birds." There is a great deal of information to be gained by analysis of the results of these flights. However, this is a research and development range. In fact, there have been almost as many different models of missiles tested as launches of one type of missile. Any attempt to form judgments from the data available must take cognizance of the small samples of data—and the numerous engineering changes made on each type as it is tested.

With that bow to the statistician, we must add the statement attributed to Lord Kelvin: "If you can't measure (assign a number to) a thing, you don't know much about it."

The data I present pertains to the boosters (rocket engines) used for satellite and space operations. For several reasons—including security—these figures should not be used as a measure of our military operational readiness. For example, most of the boosters are highly instrumented research and development birds. Only performance as it relates to a first-stage mission has been considered. With these qualifications let us look at Figs. 1-4 that show the growth of reliability for the boosters used in our space programs. This includes the performance of the booster or first stage of missile flight. Launches are scored as either successes or failures according to whether the rocket engine and guidance system operated for the programmed time. Failure to attain desired thrust and velocity is considered a failure. Each launch is weighted serially—thereby discounting early experience and weighting heavily the immediate

Abridged text of an address presented at the Seventh Annual Symposium on Reliability and Quality Control, Philadelphia, Pa., Jan. 10, 1961.

L. I. Davis is a major general of the U. S. Air Force and commander, Air Force Missile Test Center, Patrick Air Force Base, Fla.

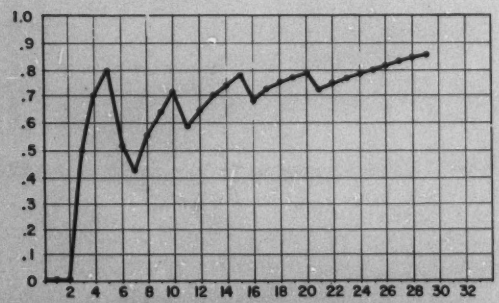


Fig. 1. Probability of booster success vs. experience—Booster X.

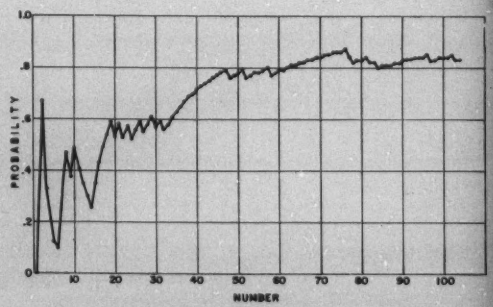


Fig. 2. Probability of success vs. experience—Booster Y.

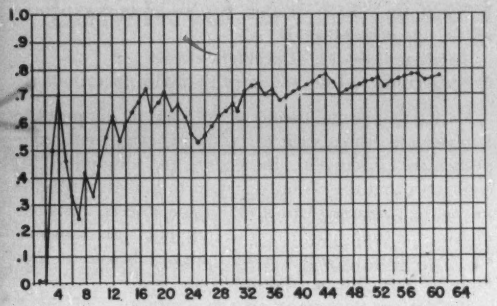


Fig. 3. Probability of booster success vs. experience—Booster Z.

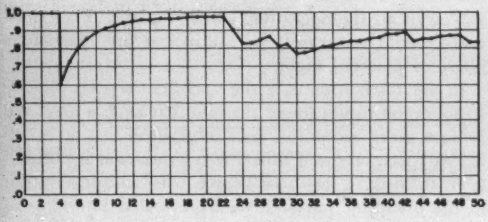


Fig. 4. Probability of success vs. experience (of the last 50 launches)—Booster Y.

past. The value associated with each launch is a measure of probability of success on the next launch.

These illustrations are indicative of our success in achieving reliability. They are quantitative—quantitative specifications of reliability of components and quantitative budgets of reliability within the subgroups of systems.

In Fig. 5 we have a composite of 44 failures out of approximately 200 launchings of missiles and first-stage boosters. These data are arranged to study the relation between the time of failure and the boost period. Failures were grouped in 5% increments of total burning time. As indicated, we experienced five failures before lift-off, four failures in the first 5% of the boost period, one failure in the next 5%, 3 in the next, and so on.

It was hoped that a study of this type would reveal a possibility of separating early failures—infant mortality type—from random failures, and "wear out failures." As a first approximation, one could write an expression relating probability of failure to per cent of burning time, postulating a term independent of time, one inversely related to time and a third proportional to time. After plotting the data I did not even bother to attempt to fit such a function to the data. It seems obvious that our failures are pretty randomly distributed throughout the powered flight phase.

In looking at this plot I am reminded of the physicist who said: "It is sometimes more fruitful to ponder on the obvious than to belabor the obscure."

In this case, it is obvious that there is no strong correlation between probability of failure and the shock of starting, or to the accumulation of strain as the acceleration builds up in the latter part of the boost period, or correlation to staging which occurs roughly at about 40% of the burn time for Atlas, or to high "q" loading that occurs roughly at this point, or to thermal effects that might increase the incidence of failures at the end of the powered flights.

I am inclined to think we must look to some factor other than design weakness for a cause and effect relationship.

OTHER KEY FACTORS IN MISSILE FAILURE

In addition to design weaknesses, we have component part unreliability and human error as causes of missile failures.

The statistical methods used in sampling millions of rounds of ammunition—and thousands of vacuum tubes and transistors—seem far removed from the problem of putting a Tiros in orbit on the first or second attempt. As for the field test engineer, I haven't got a job description for the man who might service a Midas on location, so to speak.

However, these methods and discussions are not irrelevant to the missile and space problem. As a matter of fact, we will not achieve the success we need unless we redouble our efforts—and double our expenditures—on achieving orders-of-magnitude improvement in parts reliability.

Great strides have been made in the past 2 years in the missile program; for example, the *BMD 58-10* exhibits, specifying quantitative measures of reliability to be placed in contracts. In addition, the IDEP (Interdepartmental Data Exchange Program) agreement setup by General Ritland, BMD; General Funk, AMC; Admiral Raborn, Bureau of Ordnance; and General Barkley, U.S. Army—is evidence of the strong interservice co-operation on the subject of reliability.

The third class of cause of failure is human error.

The final operational reliability is a composite of many things:

1. Quality of component parts.
2. Careful design.
3. Competent fabrication and assembly.
4. Comprehensive system engineering to insure compati-

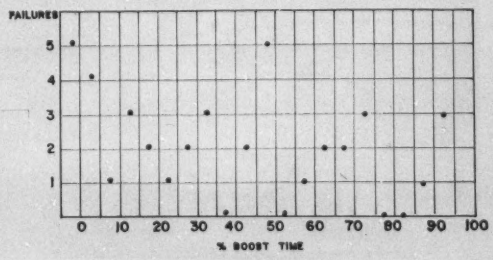


Fig. 5. Failure vs. percent of boost time.

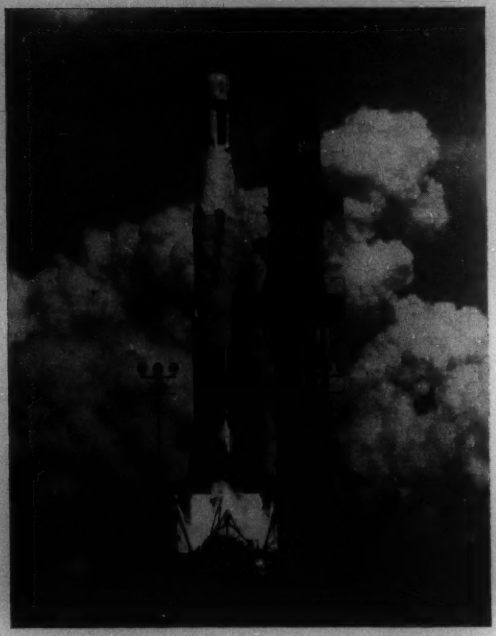


Fig. 6. Launch of Air Force Atlas-Agena.

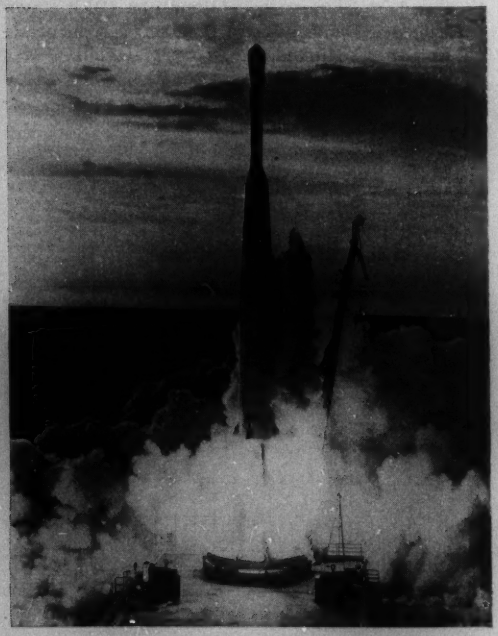


Fig. 7. Launch of Thor-Able 3-stage satellite, Tiros.

bility of the whole weapon system—ground support—all in operational mode.
5. Intelligent design of preflight checks.
6. Inspection and discipline in preflight operations.

Notice that in the listing of the parts of the problem I have used words such as: "careful, competent, comprehensive, intelligent, inspection and discipline." It is obvious that these words pertain to human attributes not to the characteristics of inanimate objects. They emphasize the dominant role the individual plays in missile reliability, whether it be design, fabrication, preflight adjustment, or inspection.

Perhaps in pondering on the significance of Fig. 5 (attempting to relate the probability of failure to some physical phenomena at a unique time in the boost) we are overlooking the obvious—that people are involved in all the operations on the missile. Their mistakes would not result in failures at any particular phase of powered flight.

In our fascination over the statistics on parts and assemblies, let us not forget the role that people play. We can not have acceptable missile performance or an efficient space program unless it is conducted by intelligent, trained, experienced people with an appreciation of the discipline required to achieve that last 10% in reliability.

The figures I have given may seem to paint a black picture of our missile and space program. If so, I have presented them in the wrong light.

We are making progress, and I am proud of our achievements. There is absolutely no reason to say that because the USSR has bigger engines they are ahead of us in the "space race."

POSITIONS COMPARED

Let us look at our present position. As of January 10, 1961, there were 17 satellites orbiting the earth. That doesn't count "space garbage"—boosters, after bodies, and so forth. Sixteen of these satellites were launched by the United States. The lone Soviet satellite is silent—dead. Of the 16 United States birds, 7 or 8 are transmitting signals.

The four lunar space probes are not supplying data—two United States launched and two USSR launched (one, of course, hit the moon). Pioneer V was still transmitting when we lost contact—some 27 million miles from home.

I said seven or eight satellites are still transmitting. We have a problem because these things can be too reliable—we do not want to accumulate a flock of birds circling the earth forever, fouling up the frequency bands. I do not know the exact number because I understand that one is being turned off on command to clear the frequency.

To me, seven or eight satellites in orbit, furnishing weather data, navigation data, data on the environment in near space, is very significant.

The key to success in space operations is reliability and the understanding of the subject that comes out of meetings like this will insure our success in the race.

Low-Level 2-Transistor Linear Rundown Circuit

D. L. ENDSLEY W. W. GRANNEMANN THOMAS SUMMERS

MOST available methods for converting pulse height to pulse width use high-amplitude pulses requiring linear amplifiers, but its size and economy make the low-level, 2-transistor circuit used here most desirable. It achieves linear rundown, and a conversion from pulse height to pulse width can be achieved by adding a differentiating circuit. The circuit forms a linear rundown activated by a constant current generator discharging a capacitor. Because the rundown length is directly proportional to pulse height, it can convert pulse height to width efficiently.

The rundown circuit (Fig. 1) uses one transistor for the constant current generator and another for the emitter follower. Fig. 2 shows the small signal equivalent circuit for Fig. 1; its analysis is in two parts because the values for C_e and r_e differ for intervals during and after pulse application. During pulse (a), transistor T_1 is biased in the forward direction. The emitter resistance r_e is 40 ohms; C_e is primarily diffusion capacity. Diffusion capacity is expressed by $C_e = 1/1.5\omega_a r_e$, where ω_a is transistor cutoff frequency and r_e its emitter resistance. During pulse application C_e is approximately 200 μμf (micromicrofarad).

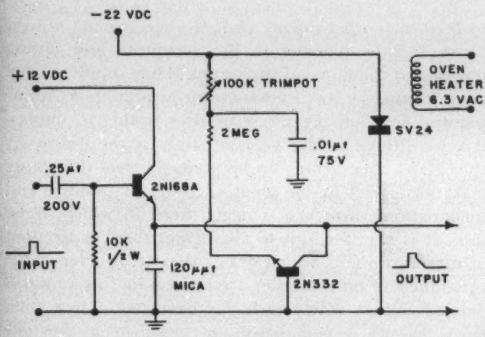


Fig. 1. Rundown circuit.

After pulse, the charge of capacitor C equals the input pulse which reverse biases T_1. Assumed are an infinite emitter resistance and an emitter to base capacitance which is the result of an estimated 5-μμf barrier capacity.

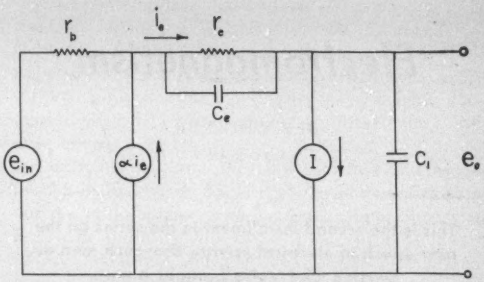


Fig. 2. Equivalent circuit ($0 \leq t \leq a$).

Solving the equivalent circuit by use of Laplace transforms, the output waveform resulting from a rectangular pulse input is a rectangular pulse followed by a small drop and a linear rundown. Two pulses of widths 5 μsec (microsecond) and 0.25 μsec and an amplitude of 1 volt were applied to the rundown circuit, Fig. 1. The theoretical and experimental waveforms agreed closely enough to plot as a single waveform.

Also, in both cases the rundown waveform dropped approximately 0.04 volt after the trailing edge of the input pulse. This drop, resulting from C_1 discharging through the barrier capacitance and base resistance, decreases rundown time, lessening its sensitivity. The effect is minimized by an emitter follower transistor with low barrier capacitance.

For gating purposes, rundown voltage is applied to a differentiating circuit obtaining a pulse width proportional to the rundown time.

A 2-transistor rundown circuit, which converts low-level pulse heights to gates, produces a linear variation of voltage with time. The linearity of rundown depends upon the constancy of the constant-current generator and ambient temperature. Because of inherent barrier capacity, the ideal waveform is unobtainable, but it may be closely approximated by using a transistor with low barrier capacity. For the circuit to perform accurately, the transistors must be kept at a constant temperature and the applied voltages must be well regulated. The circuit operates well from 0 to 3 volts; accuracies of 0.5% are possible using this circuit for pulse height to pulse width conversion together with a differentiating circuit. Achieving this accuracy means carefully selecting components and controlling temperature on all critical elements. Small temperature-controlled chambers are available with good temperature regulation. These crystal chambers plug in a tube socket and are ideal for this circuit.

Digest of paper 61-1, "A Low Level Linear Rundown Circuit for Pulse Height to Pulse Width Conversion," recommended by the AIEE Electronics Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 29-Feb. 3, 1961. Published in AIEE *Communications and Electronics*, May 1961, pp. 150-52.

D. L. Endsley, W. W. Grannemann, and Thomas Summers are with the University of New Mexico, Albuquerque, N. Mex.

OERSTED

and the Discovery of Electromagnetism

Part II

BERN DIBNER
FELLOW AIEE

This is the second installment in the series on the new epoch in electrical science that such men as Oersted and Volta brought about.

OERSTED'S boyhood represented a minimal chance of either attaining greatness or serving his people so well and over so long a span of life. He was born in the small Danish town of Rudkoebing on the island of Langeland in the south-central part of Denmark on August 14, 1777. His father Soeren was the village apothecary whose slender income made it difficult to feed his family, let alone educate them in a town without even a school. The two older boys, Hans and Anders, his junior by a year, therefore went daily to the home of a warm and friendly wigmaker nearby for instruction in German; his wife taught the two boys to read and write Danish. Other brothers later joined them for instruction with Oldenburg, the wigmaker, and also arithmetic was added to Bible reading, German, and Danish in the informal curriculum. Oldenburg's contributions were soon exhausted and the boys had to turn to a wider circle of the town's learned, such as the pastor, to supplement the simple teaching. From the town surveyor, Hans learned drawing and mathematics and, from a university student, some academic subjects. The mayor of the town taught them English and French. Whatever Hans or Anders learned separately they passed on to each other; they read every book that they could borrow in the village. At 12, Hans was sufficiently mature to help his father in the apothecary shop, which helped stimulate his interest in medicine and science. His earlier love for literature and history remained with him for his entire life.

In 1793 the brothers decided to enter the University of Copenhagen (founded in 1479) and the following spring found them at the university preparing to matriculate for the autumn session. While Hans devoted himself to the sciences of medicine, physics, and astronomy, his brother studied law. The brothers continued to help each other during their studies, sharing a joint purse, lodging together in the dormitory and dining together at the home of their aunt. They supplemented their income by small government assistance, by tutoring and economizing wherever they could. So impressive were those serious years of study at the university that Hans later wrote, "to be perfectly free, the young man must revel in the great kingdom of thought and imagination; there is a struggle there, in which, if he falls, it is easy for him to rise again, there is freedom of utterance there, which draws after it no irreparable consequences on society. . . . I lived in this onward-driving contest where each day overcame a new difficulty, gained a new truth, or banished a previous error." He openly proclaimed his pleasure in lecturing and writing about science. In this third year at the university, Hans, in 1797, was awarded the first important token of recognition, a gold medal for his essay on "Limits of Poetry and Prose." He completed his training in pharmacy also, taking his degree with high honors in 1797, and in 1799 was awarded the degree of Doctor of Philosophy along with a prize for an essay in medicine. He proposed a fresh theory of alkalis which later was accepted in chemical practices.

FERMENT OF SCIENTIFIC ACTIVITY

HAN'S STUDENT DAYS were at a time when Europe was in a new intellectual ferment following the revolutions in America and in France. Germany and Italy were rising from divisive nationalisms and a strong wave of intellectual awareness was sweeping the Continent.

The new century opened with Oersted beginning his professional career in charge of an apothecary shop in Copenhagen and as lecturer at the university. He was stirred by the announcement of Volta's discovery of chemical electricity and he immediately applied the voltaic pile to experiments with acids and alkalis. The following year he devoted to the customary "Wanderjahr," traveling in Germany, France, and the Netherlands, meeting the philosophers Schelling, Fichte, and

This article is a serialization, in four parts, of the book of the same name published by the Burndy Library, Norwalk, Conn.

Bern Dibner is chairman of the board, Burndy Corporation, Norwalk, Conn.

Tieck. He also met Count Rumford (born Benjamin Thompson in Woburn, Mass.) who was then serving the Elector of Bavaria, and the physicist Ritter; these were Oersted's main contacts in science.

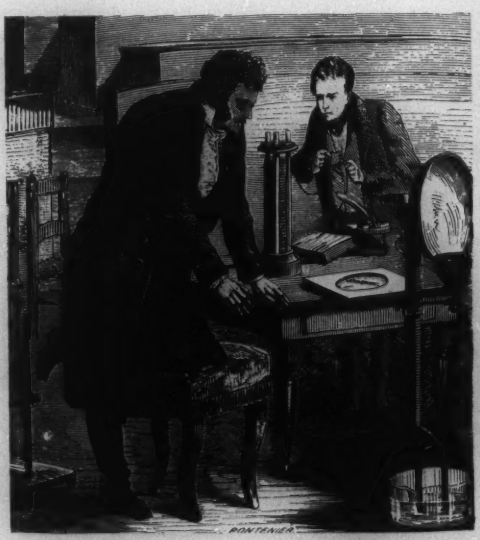
From Göttingen (1801) where he stayed for 10 days, he wrote, "The first question asked everywhere is about galvanism. As everybody is curious to see the battery of glass tubes I have invented, I have had quite a small one made here of four glass tubes (in Copenhagen I used 30) and intend to carry it with me." Oersted joined Ritter at Jena and stayed with him for 3 weeks, continuing their correspondence after he left. With Ritter he was exposed to the fantastic profusion of ideas that stormed through his host's fertile but disorganized mind. Oersted remodeled Ritter's notes into an essay in French which was submitted to the Institut de France for its annual prize of 3,000 francs. The sound discoveries of this quixotic genius were so diluted by those of fantasy that the prize was never awarded to him. In May, 1803, Ritter, in another flight of fancy, wrote to Oersted a letter that contained a remarkable prophecy. He related events on earth to periodic celestial phenomena and indicated that the years of maximum inclination of the ecliptic coincided with the years of important electrical discoveries. Thus, 1745 corresponded to the invention of the "Leiden" jar by Kleist, 1764 that of the electrophorus by Wilcke, 1782 produced the condenser of Volta, and 1801 the voltaic pile. Ritter proceeded, "You now emerge into a new epoch in which late in the year 1819 or 1820, you will have to reckon. This we might well witness." Ritter died in 1810 and Oersted not only lived to see the event occur but was the author of it.

In 1803 Oersted returned to Copenhagen and applied for the university's chair in physics but was rejected because he was probably considered more a philosopher than a physicist. However, he continued experimenting and lecturing, publishing the results of his experiments in German and Danish periodicals. In 1806 his ambition was realized and he became professor of physics at the Copenhagen University, though not realizing full professorship (ordinarius) until 1817.

During Oersted's attendance at the university, it was poorly equipped with physical apparatus for experimenting in the sciences. He was, however, fortunate in his contact with Prof. J. G. L. Manthey (1769-1842), teacher of chemistry, who, in addition to his academic chair, was also proprietor of the "Lion Pharmacy" in Copenhagen where Oersted assisted him. Manthey maintained a valuable collection of physical and chemical apparatus which was at Oersted's disposal during and after his graduation. In 1800, Manthey went abroad and Oersted was appointed manager of the Lion Pharmacy. In February 1801, Oersted did manage to experiment with physical apparatus and reported experiments made with a voltaic battery of 600 plates of zinc and silver and of later experiments with a battery of 60 plates of zinc and lead. In the following year, 1803, Oersted, simultaneously with Davy, discovered that acids increased the strength of a voltaic battery more than did salts. Eager as he was to pursue this promising line, he was so loaded down with the management of the pharmacy and lectures in the medical and pharmaceutical faculties at the university that he could devote only Sunday afternoons to "galvanizing."

He assumed his academic career with the same intensity and thoroughness that had marked every step in his rise from boyhood. The university was the only one in Denmark and the status of professor represented the upper social level. His broad interest in literary, political, and philosophical movements opened many doors to him. His friends were numerous and their ties to him were strong.

The years 1812 and 1813 saw him in Germany and France again, but on this visit to Berlin he did not seek out the philosophers as he had on his first journey. In Berlin he published his views of the chemical laws of nature in German and this was issued in French translation (Paris, 1813) under the title *Recherches sur l'identité des forces chimiques et électriques*, a work held in very high esteem by the new generation of research chemists. His interest in finding a relationship between voltaic electricity and magnetism is here first indicated. Chapter VIII is entitled "On Magnetism" and in it are included such remarks as, "One has always been tempted to compare the magnetic forces with the electrical forces. The great resemblance between electrical and magnetic attractions and repulsions and the similarity of their laws necessarily would bring about this comparison. It is true, that nothing has been found comparable with electricity by communication;

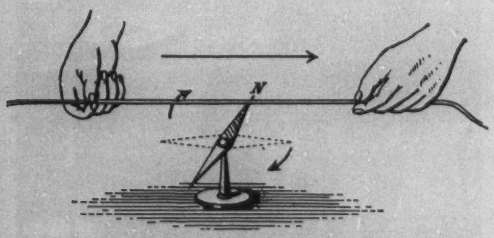


Lecturing before a select group of students, Oersted, in the spring of 1820, noticed that the needle of a nearby magnetic compass deviated when the circuit of a voltaic pile was completed. On July 21, the discovery of electromagnetism was announced.

but the phenomena observed had such a degree of analogy to those depending on electrical distribution that one could not find the slightest difference. . . . The form of galvanic activity is halfway between the magnetic form and the electrical form. There, forces are more latent than in electricity, and less than in magnetism. . . . But in such an important question, we would be satisfied if the judgment were that the principal objection to the identity of forces which produce electricity and magnetism were only a difficulty, and not a thing which is contrary to it. . . . One could also add to these analogies that steel loses its magnetism by heat, which proves that steel becomes a better conductor through a rise in temperature, just as electrical bodies do. It is also found that magnetism exists in all bodies of nature, as proven by Bruckmann and Coulomb. By that, one feels that magnetic forces are as general as electrical forces. An attempt should be made to see if electricity, in its most latent stage, has any action on the magnet as such." His plan and intent were clearly charted.

Oersted returned in 1814 and resumed an active part in university and political discussions. In one debate he supported the freedom of judgment as opposed to dogma, in another he held that the practice of science was in fact an act of religious worship. He continued as a popular lecturer. He devised a detonating fuse in which a short wire was caused to glow by an electric current.

In 1819 under royal command he undertook a very successful geological expedition to Bornholm, one of the Danish islands, being one of three scientists in the expedition. It was with the assistance of one of the members of this expedition, Lauritz Esmarch, that Oersted succeeded in producing light by creating an electric discharge in mercury vapor through which an electric current was made to flow. Together they also developed a new form of voltaic cell in which the wooden trough was replaced by one of copper, thereby producing stronger currents. Esmarch was among those who witnessed Oersted's first demonstration of his discovery.



In essence, Oersted's discovery was that a wire carrying an electric current affected an adjacent magnetic needle by causing it to swerve to a position perpendicular to the direction of the wire. When the current was reversed, the needle swung diametrically about. When the wire was placed under the needle, it pointed in the opposite direction, indicating a magnetic field circular in form around the conductor.

DISCOVERY OF ELECTROMAGNETISM

THE ASSOCIATION between electric (both electrostatic and voltaic) forces and magnetic forces had been recognized by investigators for many decades. Electrical literature contained numerous references to lightning that had magnetized iron and had altered the polarity of compass needles. In the late 1700's Beccaria and van Marum, among others, had magnetized iron by sending an electrostatic charge through it. Beccaria had almost stumbled on a lead to the relationship between electricity and magnetism when a discharge from a Leyden jar was sent *transversally* through a piece of watch-spring steel making its ends magnetic. The resulting magnetic effect proved stronger than when the discharge was made lengthwise. The experiments of Romagnosi and others have already been noted but no one had determined the cause-and-effect relationship between these two primary forces. Oersted's own earlier experiments were unimpressive, possibly because he had, like other experimenters, laid the conducting wire across the compass needle instead of parallel with it.

The sequence of events leading to his important discovery still remains ambiguous but it seems that one of the advanced students at the university related that the first direct event that led to the publication of Oersted's discovery occurred during a private lecture made before a group of other advanced students in the spring of 1820. At this lecture Oersted happened to place the conducting wire over and parallel to a magnetic needle. Another student related that the experiment concerned the heating of some platinum wire by means of an electric current and that a compass needle happened by chance to be near and underneath the conducting wire. In any case, Oersted observed the needle to swing strongly aside as though a magnet had been moved close to it. Not much was said or done at the moment but the challenging problem had fixed itself in Oersted's mind, and later, using a more powerful battery and larger conductor, he repeated the experiment with startling results. He then organized the problem, formulated the observations, and arrived at a set of conclusions which he prepared into one of the most famous and rare bits of scientific literature. This four-page tract appeared on July 21, 1820 in Latin, bearing the title *Experimenta circa effectum conflictus electrici in acum magneticam*. It announced that an electric current in a conductor created a circular magnetic field around the conductor. Further, if a magnetic needle is brought into the field surrounding the wire, it will set itself tangent to the circular field, continuing its tangential position if the needle is carried around the wire, pointing in one direction beneath the wire and in the opposite direction when above it. If the direction of current is reversed in the conductor, the direction of the needle is similarly reversed from its former position. Various substances interposed between wire and needle had no effect on the latter. Incredibly simple as this relationship seems to be, it remained unobserved during two decades of investigation by many penetrating minds.

Oersted's failure to publish a detailed account of how he came upon his discovery, of exactly what the series of confirming experiments consisted, or the time and place of each step in the process of clarification have left an area of uncertainty that has never quite been filled. Five general accounts have been left to us by Oersted concerning events connected with the discovery. The earliest of these was published in Danish before April 1821 and was immediately followed by two equivalent accounts in German and French also probably prepared by Oersted. In these accounts Oersted wrote: "I was brought back to them (experiments on the effects of an electric current on a magnet) through my lectures on electricity, galvanism, and magnetism in the spring of 1820. The auditors were mostly men already considerably advanced in science; so these lectures and the preparatory reflections led me on to deeper investigations than those which are admissible in ordinary lectures. Thus my former conviction of the identity of electrical and magnetic forces developed with new clarity, and I resolved to test my opinion by experiment. The preparations for this were made on a day in which I had to give a lecture on the same evening. I there showed Canton's experiment on the influence of chemical effects on the magnetic state of iron. I called attention to the variations of the magnetic needle during a thunderstorm, and at the same time I set forth the conjecture that an electric discharge could act on a magnetic needle placed outside the galvanic circuit. I then resolved to make the experiment. Since I expected the greatest effect from a discharge associated with incandescence, I inserted in the circuit a very fine platinum wire above the place where the needle was located. The effect was certainly unmistakable, but still it seemed to me so confused that I postponed further investigation to a time when I hoped to have more leisure. At the beginning of July these experiments were resumed and continued without interruption until I arrived at the results which have been published."

LATER ACCOUNTS

THE TWO later accounts of the genesis of his discovery were written in 1827. One was in autobiographical form. Looking back on the 7 years since the announcement of his discovery, Oersted referred to his epochal paper, "This half-sheet was now sent on the same post day to the most important scientific centers in Europe. The experiments were soon repeated in all countries in which there were friends of science and the greatest reward an inventor can enjoy, that of seeing his invention become the object of the most industrious investigation, seeing it expanded and fructifying, was his to the fullest. The number of those who have written on electromagnetism amounts to well over a hundred. Therefore, with the united efforts of so many, this knowledge too has been expanded and enriched in content far beyond what one would expect in the short period of seven years."

The fifth account Oersted prepared in English for the *Edinburgh Encyclopedia*, 1830, and it appeared as an article entitled "Thermo-Electricity." Using the third person, Oersted reviewed the history of magnetic effects resulting from electric charges, including the investigations of Franklin, Wilcke, and van Marum. He then referred to the report on Mojon's experiment "that a steel needle having been 22 days in communication with a galvanical apparatus of 100 elements, had become magnetical—an experiment which would have been of no historical interest, if its author had not founded upon it, 18 years later, a pretension to the discovery of electromagnetism." He then referred to Aldini's mention of Romagnosi and added,

The actual magnetic compass used by Oersted in the revealing experiment of 1820 is still in the possession of the Polytechnic Institute of Copenhagen. It is shown resting on one of the very few surviving copies of the epochal announcement, in Latin, of his discovery of electromagnetism.

"It is, therefore, not surprising that neither the French institute, nor the other learned societies, nor the numerous natural philosophers, to which the work was presented in the year 1804, took any notice of this observation, which would have accelerated the discovery of electromagnetism by sixteen years. Romanesi seems likewise to have forgot his observation, until electromagnetism was discovered." He then stated that "Electromagnetism itself, was discovered in the year 1820, by Professor Hans Christian Oersted, of the University of Copenhagen. Throughout his literary career, he adhered to the opinion, that the magnetical effects are produced by the same powers as the electrical. In a treatise . . . translated into French, 1813, he endeavored to establish a general chemical theory, in harmony with this principle. In this work, he proved that not only chemical affinities, but also heat and light are produced by the same two powers, which probably might be only two different forms of one primordial power. In the winter of 1819-20, he delivered a course of lectures upon electricity, galvanism and magnetism, before an audience that had been previously acquainted with the principles of natural philosophy. In composing the lecture, in which he was to treat of the analogy between

The announcement of Oersted's important discovery of electromagnetism prompted André-Marie Ampère, professor of mathematics in Paris, to formulate the laws of action between conductors carrying an electric current. Attraction and repulsion were determined for straight and formed conductors, the magnetic behavior of solenoids explored, a galvanometer proposed, and an electromagnetic telegraph indicated.

magnetism and electricity, he conjectured, that if it were possible to produce any magnetical effect by electricity, this could not be in the direction of the current, since this had been so often tried in vain, but that it must be produced by a lateral action. . . . As the luminous and heating effect of the electrical current, goes out in all directions from a conductor, which transmits a great quantity of electricity; so he thought it possible that the magnetical effect could likewise eradiate. . . . The plan of the first experiment was, to make the current of a little galvanic trough apparatus, commonly used in his lectures, pass through a very thin platina wire, which was placed over a compass covered with glass. The preparations for the experiments were made, but some accident having hindered him from trying it before the lecture, he intended to defer it to another opportunity; yet during the lecture, the probability of its success appeared stronger, so that he made the first experiment in the presence of the audience. The magnetical needle, though included in a box, was disturbed; but as the effect was very feeble, and must, before its law was discovered, seem very irregular, the experiment made no strong impression on the audience. It may appear strange, that the discoverer made no further experiments upon the subject during three months. . . . In the month of July 1820, he again resumed the experiment, making use of a much more considerable galvanical apparatus. The success was now evident, yet the effects were still feeble in the first repetitions of the experiment, because he employed only very thin wires, supposing that the magnetical effect would not take place, when heat and light were not produced by the galvanical current; but he soon found that conductors of a greater diameter give much more effect; and he then discovered, by continued experiments during a few days, the fundamental law of electromagnetism, viz. *that the magnetical effect of the electrical current has a circular motion around it.*"

From this it seems quite clear that Oersted expected a magnetic effluent from this electric wire in concert with the heat and the light which he knew would evolve from the glowing wire. He was conscious of the failure of previous experimenters, particularly Ritter, to observe any magnetism present, and that prompted considerable caution. In his attempt to reconcile the interaction of the new forces he retained the idea of an "electrical conflict," meaning the discharge between opposite electricities that occurred along a spiral line about the axis of the conductor and the magnetism that surrounded it. He considered heat and light also to be manifestations of an electrical conflict, each accompanied by circular motions such as the demonstrable magnetic field around a current-carrying wire.

Another source of information as to what occurred, but remained unreported during those critical months, was a letter dated December 30, 1857 from a former pupil and friend of Oersted, Christopher Hansteen, writing to Faraday. According to this account Oersted tried placing the wire of the battery perpendicular to the magnetic needle, but observed no motion. However, towards the end of a lecture, Oersted tried the wire parallel with the needle and saw the needle swing into a right-angle position. Oersted was then supposed to have inverted the direction of the current and to have seen the needle swing into an opposite position. However, this report was made 37 years after the event by one not present at the lecture. It is much more probable that after the observation by Oersted of the first successful result, he waited three months in order to construct a more powerful battery and then, in July 1820, a series of experiments confirmed his original observation and he then felt ready to announce his discovery.

In these later experiments, some 60 in number, he observed no decrease in magnetic effect even through screens of wood, glass, marble, clay, water, etc. Another impressive observation was that made when the magnetism produced by the electric current acted upon a magnet being held in position by yet another magnet. Similarly, different kinds of wire to carry the current —platinum, gold, silver, brass, iron, ribbons of lead and tin, even a pool of mercury—all proved equally effective. Many manuscript notes of Oersted's experiments are dated throughout the first three weeks of July, and especially many occurred on July 15. No further time was to be lost in announcing the discovery.

The four-page announcement was transmitted on the day of publication to learned societies and scholars in all European countries. The following is a translation from a printed account drawn up in Latin by the author, and transmitted by him to the editor of the *Annals of Philosophy:*

Experiments on the Effect of a Current of Electricity on the Magnetic Needle.

THE first experiments respecting the subject which I mean at present to explain, were made by me last winter, while lecturing on electricity, galvanism, and magnetism, in the University. It seemed demonstrated by these experiments that the magnetic needle was moved from its position by the galvanic apparatus, but that the galvanic circle must be complete, and not open, which last method was tried in vain some years ago by very celebrated philosophers. But as these experiments were made with a feeble apparatus, and were not, therefore, sufficiently conclusive, considering the importance of the subject, I associated myself with my friend Esmarck to repeat and extend them by means of a very powerful galvanic battery, provided by us in common. Mr. Wleugel, a Knight of the Order of Danneborg, and at the head of the Pilots, was present at, and assisted in, the experiments. There were present likewise Mr. Hauch, a man very well skilled in the Natural Sciences, Mr. Reinhardt, Professor of Natural History, Mr. Jacobsen, Professor of Medicine, and that very skillful chemist, Mr. Zeise, Doctor of Philosophy. I had often made experiments by myself; but every fact which I had observed was repeated in the presence of these gentlemen.

The galvanic apparatus which we employed consists of 20 copper troughs, the length and height of each of which was 12 inches; but the breadth scarcely exceeded 2½ inches. Every trough is supplied with two plates of copper, so bent that they could carry a copper rod, which supports the zinc plate in the water of the next trough. The water of the troughs contained 1/60th of its weight of sulphuric acid, and an equal quantity of nitric acid. The portion of each zinc plate sunk in the water is a square whose side is about 10 inches in length. A smaller apparatus will answer provided it be strong enough to heat a metallic wire red hot.

The opposite ends of the galvanic battery were joined by a metallic wire, which, for shortness sake, we shall call the *uniting conductor*, or the *uniting wire*. To the effect which takes place in this conductor and in the surrounding space, we shall give the name of the *conflict of electricity*.

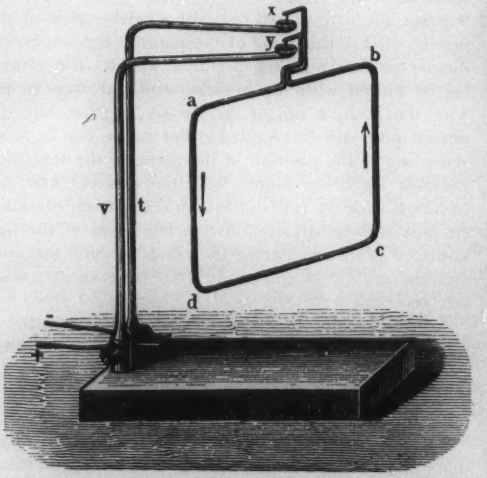
Let the straight part of this wire be placed horizontally above the magnetic needle, properly suspended, and parallel to it. If necessary, the uniting wire is bent so as to assume a proper position for the experiment. Things being in this state, the needle will be moved, and the end of it next the negative side of the battery will go westward.

If the distance of the uniting wire does not exceed three-quarters of an inch from the needle, the declination of the needle makes an angle of about 45°. If the distance is increased, the angle diminishes proportionally. The declination likewise varies with the power of the battery.

The uniting wire may change its place, either towards the east or west, provided it continue parallel to the needle, without any other change of the effect than in respect to its quantity. Hence the effect cannot be ascribed to attraction; for the same pole of the magnetic needle, which approaches the uniting wire, while placed on its east side, ought to recede from it when on the west side, if these declinations depended on attractions and repulsions. The uniting conductor may consist of several wires, or metallic ribbons, connected together. The nature of the metal does not alter the effect, but merely the quantity. Wires of platinum, gold, silver, brass, iron, ribbons of lead and tin, a mass of mercury, were employed with equal success. The conductor does not lose its effect, though interrupted by water, unless the interruption amounts to several inches in length.

The effect of the uniting wire passes to the needle through glass, metals, wood, water, resin, stoneware, stones; for it is not taken away by interposing plates of glass, metal or wood. Even glass, metal, and wood, interposed at once, do not destroy, and indeed scarcely diminish the effect. The disc of the electrophorus, plates of porphyry, a stone-ware vessel, even filled with water, were interposed with the same result. We found the effects unchanged when the needle was included in a brass box filled with water. It is needless to observe that the transmission of effects through all these matters has never before been observed in electricity and galvanism. The effects, therefore, which take place in the conflict of electricity are very different from the effects of either of the electricities.

If the uniting wire be placed in a horizontal plane under the magnetic needle, all the effects are the same as when it is above the needle, only they are in an opposite direction; for the pole of the magnetic needle



A current-carrying loop was pivoted by Ampère free to move on its vertical axis. The loop ends were set into mercury-filled cups and when the current was applied the loop moved until its electromagnetism coincided with that of earth's magnetism.

next the negative end of the battery declines to the east.

That these facts may be the more easily retained, we may use this formula—the pole *above* which the *negative* electricity enters is turned to the *west; under* which, to the *east.*

If the uniting wire is so turned in a horizontal plane as to form a gradually increasing angle with the magnetic meridian, the declination of the needle *increases,* if the motion of the wire is towards the place of the disturbed needle; but it *diminishes* if the wire moves further from that place.

When the uniting wire is situated in the same horizontal plane in which the needle moves by means of the counterpoise, and parallel to it, no declination is produced either to the east or west; but an *inclination* takes place, so that the pole, next which the negative electricity enters the wire, is *depressed* when the wire is situated on the *west* side, and *elevated* when situated on the *east* side.

If the uniting wire be placed perpendicularly to the plane of the magnetic meridian, whether above or below it, the needle remains at rest, unless it be very near the pole; in that case the pole is *elevated* when the entrance is from the *west* side of the wire, and *depressed,* when from the *east* side.

When the uniting wire is placed perpendicularly opposite to the pole of the magnetic needle, and the upper extremity of the wire receives the negative electricity, the pole is moved towards the east; but when the wire is opposite to a point between the pole and the middle of the needle, the pole is most towards the west. When the upper end of the wire receives positive electricity, the phenomena are reversed.

If the uniting wire is bent so as to form two legs parallel to each other, it repels or attracts the magnetic poles according to the different conditions of the case. Suppose the wire placed opposite to either pole of the needle, so that the plane of the parallel legs is perpendicular to the magnetic meridian, and let the eastern leg be united with the negative end, the western leg with the positive end of the battery: in that case the nearest pole will be repelled either to the east or west, according to the position of the plane of the legs. The eastmost leg being united with the positive, and the westmost with the negative side of the battery, the nearest pole will be attracted. When the plane of the legs is placed perpendicular to the place between the pole and the middle of the needle, the same effects recur, but reversed.

A brass needle, suspended like a magnetic needle, is not moved by the effect of the uniting wire. Likewise needles of glass and of gum lac remain unacted on.

We may now make a few observations towards explaining these phenomena.

The electric conflict acts only on the magnetic particles of matter. All non-magnetic bodies appear penetrable by the electric conflict, while magnetic bodies, or rather their magnetic particles, resist the passage of this conflict. Hence they can be moved by the impetus of the contending powers.

It is sufficiently evident from the preceding facts that the electric conflict is not confined to the conductor, but dispersed pretty widely in the circumjacent space.

From the preceding facts we may likewise collect that this conflict performs circles; for without this condition, it seems impossible that the one part of the uniting wire, when placed below the magnetic pole, should drive it towards the east, and when placed above it towards the west; for it is the nature of a circle that the motions in opposite parts should have an opposite direction. Besides, a motion in circles, joined with a progressive motion, according to the length of the conductor, ought to form a conchoidal or spiral line; but this, unless I am mistaken, contributes nothing to explain the phenomena hitherto observed.

All the effects on the north pole above-mentioned are easily understood by supposing that negative electricity moves in a spiral line bent towards the right, and propels the north pole, but does not act on the south pole. The effects on the south pole are explained in a similar manner, if we ascribe to positive electricity a contrary motion and power of acting on the south pole, but not upon the north. The agreement of this law with nature will be better seen by a repetition of the experiments than by a long explanation. The mode of judging of the experiments will be much facilitated if the course of the electricities in the uniting wire be pointed out by marks or figures.

I shall merely add to the above that I have demonstrated in a book published five years ago that heat and light consist of the conflict of the electricities. From the observations now stated, we may conclude that a circular motion likewise occurs in these effects. This I think will contribute very much to illustrate the phenomena to which the appellation of polarization of light has been given.

JOHN CHRISTIAN OERSTED.
Copenhagen, July 21, 1820.

(The third article of the series will appear in the August issue.)

Tower "Topped Out" by 'Copter

A 200-foot-tall steel transmission tower was "topped out" 4 days ahead of schedule recently when a Hiller 12E light utility helicopter airlifted 93 feet of the structure in half-ton steel sections to within arm's reach of riggers.

The entire project, from the 111-foot level until the last insulator was bolted in place, took only 4½ hours of flying time by the 305-hp Hiller, which itself weighs only 1,700 pounds.

According to officials of Pacific Power and Light Company, Tyee Construction Co., and Columbia Helicopters, it was the first time a light helicopter had been used to erect a heavy steel structure.

A Proposed Electronic Method for High-Speed Teleprinters

N. N. BISWAS
ASSOCIATE MEMBER AIEE

Features of a proposed electronic method for the transmission and reception of teleprinter code are described. Advantages include high accuracy of reception, variable speed, and substantial savings in cost and maintenance.

IT IS a common experience of communication engineers of today that much telegraph apparatus which was originally developed for conventional telegraph applications is finding more and more use in other fields, notably in the developing art of data communication. This has its inevitable influence on the design of the telegraph equipments. In this article a new method for transmission and reception of teleprinter code is described. This is an improvement over the author's original proposal published in 1958.[1]

TRANSMISSION AND RECEPTION

Fig. 1(A) shows the 7.5-unit start-stop teleprinter code for the word NEW, while Fig. 1(B) shows the proposed new method, assuming 20 milliseconds as the duration of each code element in both systems to facilitate comparison. The noteworthy features of the new method are as follows:

1. The start signal is replaced by a reset signal *RS*, consisting of two positive pulses separated by a NO pulse, each of 10 milliseconds duration.

2. The stop pulse is replaced by a negative pulse of 10 milliseconds duration.

3. A space is transmitted by a NO pulse and a mark by positive pulse of 10 milliseconds duration. Each space or mark is preceded by a negative pulse of the same duration.

4. During periods of no transmission—that is, when the line is idle—there is no current flowing in the line. In the existing system, marking current flows onto the line during idle period.

5. The code always needs a double-current system for its transmission, whereas the existing system can be transmitted in a single- or a double-current system.

From Fig. 1(B) it can be seen that each character has 14 units, each unit being of 10 milliseconds duration.

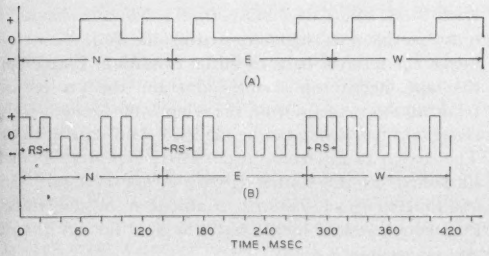


Fig. 1. Current waveform for the word NEW in the existing and proposed methods.

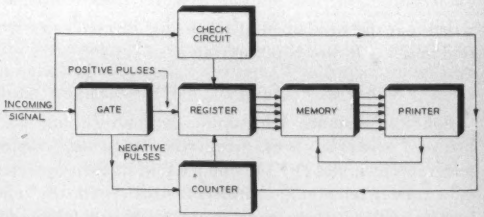


Fig. 2. Block diagram of electronic receiver.

In this method the teleprinter receiver is completely electronic. It recognizes the teleprinter signal serially, but feeds a mechanical printer with a 5-wire parallel input. The block diagram of such a receiver is shown in Fig. 2. The incoming signal encounters a gate and a check circuit. The gate diverts the negative pulses to the counter and the positive pulses to the register, which can store five bits of information in five locations. The reset signal is unique in that it has two consecutive positive pulses with no negative pulse between. The check circuit produces a pulse output only when it receives the reset signal. This pulse resets the counter and register to the initial conditions. When the counter receives the first negative pulse, the register is conditioned to store the incoming information, which may be a positive pulse in case of mark or no pulse in case of space, in the first location. In this way the register

Full text of paper 61-29, presented at the AIEE Winter General Meeting, New York, N.Y., Jan. 29-Feb. 3, 1961. Recommended for publication by the AIEE Telegraph Systems Committee. Published in AIEE *Communication and Electronics*, May 1961, pp. 115-17.

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The author wishes to thank W. Y. Lang of the Bell Telephone Laboratories, Inc., for many valuable discussions about the proposed method.

stores the code of the incoming character as a parallel output. When the counter receives the last and sixth negative pulse, the code stored in the register is transferred to the memory; the register comes back to initial condition and becomes free to receive the next code train. When the next code train is being received by the counter and register, the memory actuates the printer to print the character stored in it.

SPEED AND BANDWIDTH

IT CAN BE SEEN that this method does not require any synchronization between the transmitter and receiver. Thus, in this system the teleprinter receiver can receive signals transmitted at any speed, provided that the pulse duration is broad enough to be within the operating limit of the electronic elements of the counter and register units. Since an electronic circuit can operate even in a few microseconds, the speed of transmission can be enhanced to a great extent. The ultimate limit, however, will depend on the type of output required. Assuming six characters per word, speed in words per minute S has the following relation with pulsewidth in milliseconds W

$$W = 5{,}000/7S \tag{1}$$

The curve plotted in Fig. 3 shows that even at such high speed as 3,000 words per minute the pulse width is as broad as 240 microseconds. The fundamental frequency of signaling along with the third harmonic are plotted against speed in Fig. 4, based on the relation

$$f = 0.7S \tag{2}$$

where f is the fundamental frequency in cycles per second and S is in words per minute.

CARRIER OPERATION WITHOUT VFT

FOR long-distance telegraphic communication, teleprinters generally work with voice-frequency carrier telegraph terminal (VFT). The VFT in its turn operates on a carrier telephone channel. In this system the teleprinter signal can be made to modulate the telephone channel directly, eliminating the VFT completely. It can be computed from equation 2 or Fig. 4 that with a bandwidth of 3,000 cps a speed of 1,428 words per minute can be achieved, assuming that third harmonic is essential to maintain signal shape. Thus, if the teleprinter transmitter and receiver can operate at such high speed, the VFT can be eliminated by two high-speed teleprinters, one at the transmitting and the other at the receiving end. Although the electronic portion can be easily designed for such high speed, the printing mechanism offers some difficulties. However, high-speed printers have been developed to meet the demand of increased speed.[2] If high-speed printers are not available, then the signal can be recorded on high-speed reperforators. The reperforated tape then can be driven slowly to obtain page or tape print-outs on the usual machine.

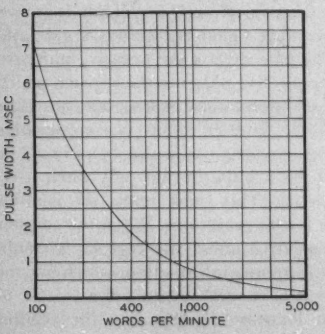

Fig. 3. Pulse width vs. speed.

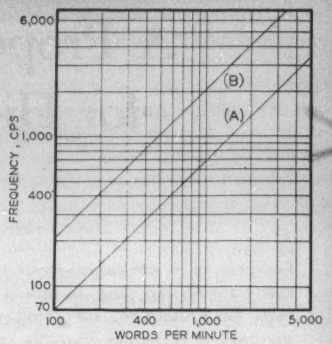

Fig. 4. Signaling frequency vs. speed for (A) fundamental frequency and (B) third harmonic.

CONCLUSION

IN THIS SYSTEM the teleprinter receiver has great freedom of operation. It no longer remains a single-speed machine, but can receive messages at a continuously variable speed without requiring manual adjustment. Moreover, the accuracy of reception depends on the detection of pulses and their polarities rather than their relative durations. Hence bias and other types of distortion which critically affect existing receivers, are less likely to introduce error. If, somehow, the line breaks or one negative pulse is lost during transmission, the error is not cumulative but is confined to one character only, as the reset signal preceding the code elements brings the receiver back to initial condition. Except for the tape mechanism at the input and the printer or reperforator at the output, the teleprinter is completely electronic and hence can be made of solid-state devices. The design of electronic regenerative repeaters is also simplified, as the timing circuit is not necessary. In addition to these features, elimination of the voice-frequency terminal should result in great savings in cost and maintenance.

It may also be mentioned here that although the proposed method has been described with particular reference to teleprinter, it can also be extended to the field of digital data communication.

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Incremental and Conventional Digital Computers in Air-Borne Real-Time Control

S. M. SHACKELL J. G. TRYON

The relative merits of incremental and conventional digital computers in air-borne real-time control are discussed on the basis of reliability, flexibility, and the specific applications to be considered.

THE AUTOPILOT is a typical air-borne real-time control computer. It guides a physical system along a prescribed path. Digital computers are beginning to be used in such systems, and the question is "Which is better, the digital differential analyzer or the general-purpose digital computer?"

Before answering the question, we ought to say that the digital differential analyzer has grown up. It is no longer simply a differential analyzer. It can do, in principle, any calculation that a general-purpose machine can do, with equal exactness. It can do algebraic and trigonometric calculation; it can make and implement decisions; it can correct errors. This type is called an incremental computer—a machine that computes according to a special incremental arithmetic. The general-purpose machine is referred to as conventional.

ESSENTIAL DIFFERENCE

IN EXPLAINING the essential difference between the two designs, we must first observe that all real-time control computers have this in common: They have inputs and outputs which are functions of time. As the inputs change with time, the computers cyclically recalculate. They calculate changed values of the outputs corresponding to each new set of input values. Furthermore, as their calculations proceed, all computers evaluate intermediate quantities. Although these intermediate quantities are necessary to the calculation of the outputs, they are not outputs.

The essential difference is that in the incremental computer the intermediate quantities and outputs are retained from cycle to cycle and brought up to date in each cycle. Changes in the inputs since the last calculation are propagated through the calculation as changes in the intermediate quantities to become changes in the outputs. In the conventional computer, on the other hand, the intermediate quantities and outputs of one cycle are discarded and have no use in the next recalculation. Each quantity is recomputed afresh in each cycle; there is no essential holdover from previous cycles. (Apparent exceptions occur in prediction and similar calculations.)

The two machines are rather like two computresses who must do the same calculation over and over again with slightly different inputs. Miss Incremental patiently corrects her old worksheet when a new batch of numbers comes along, figuring the new values by calculating changes in the old ones and adding them in. Miss Conventional tears up her old worksheet in disgust when new values are given to her, and then starts over.

COMPARISON

ALTHOUGH the capabilities of the two computers are in principle the same, they are in practice very different. The differences all arise out of one fact. The incremental need only deal with small changes in values, and for economy's sake is so built that it is restricted to handling these small changes. The conventional machine, on the other hand, must be and is able to deal with any values that come along, no matter how different they may be from preceding values.

Let us compare typical air-borne computers. These are not equivalent computers. They are ones well proportioned to their jobs, which are different because the characteristics of the machines are different. All numbers are estimates. Relative values are rather reliable, but absolute values are less dependable (probably good to a factor of 3). The numbers are based on drum storage in the incremental computer, core storage in the conventional, and transistor circuitory in both—all as of about 1956. Much water has gone over the dam since 1956, but we still feel that the values will be helpful. Estimates of reliability are based on laboratory experience, with a heavy factor to allow for the harshness of service conditions.

The incremental computer is fast in the sense that it recalculates new values frequently. Thus the signal bandwidth that it can handle is high—as high as 25 cps. It is fast because it need only deal with changes in quantities. The changes that it handles in each cycle, however, are limited in magnitude. Slewing times accordingly are long. In this sense, the incremental is quite slow. (Slewing time is the time required for the computer to accomplish a large change in its outputs.)

A condensation of paper 60-120, presented at the AIEE Winter General Meeting, New York, N. Y., Jan. 31–Feb. 5, 1960. Recommended for publication by the AIEE Computing Devices Committee. Published in AIEE *Communication and Electronics*, Sept. 1960, pp. 393-400.

S. M. Shackell, deceased, was with Stevens Institute of Technology, Hoboken, N. J., and J. G. Tryon, formerly with the Bell Telephone Laboratories, Inc., Whippany, N. J., is with the University of Alaska, College, Alaska. This work was supported by the U. S. Air Force. Opinions presented here do not necessarily represent Air Force opinion.

In an incremental computer, it can run as high as 300 seconds. In short, an incremental computer is rate-limited.

The conventional machine, on the other hand, tends to be slow in that it recalculates new values relatively infrequently. This is because it must work out all calculations completely. It is frequency-limited. Bandwidth is about 2.5 cps. However, since each new set of outputs is independent of the previous set, slewing time is short. In this sense, the conventional machine is fast. A typical value for slewing time is 0.1 second.

Sometimes wide bandwidth is wanted, sometimes short slewing time, and sometimes both. It all depends on the problem. We should observe that fast slewing is needed when decisions are implemented or errors corrected, as well as when inputs change sharply. Each of these actions requires large changes in outputs.

Turning to physical size, we observe that incrementals are small and have fewer parts. Volume and weight are perhaps half that of a conventional machine. Perhaps only one quarter as many parts are needed. These savings may be very desirable.

Because they have fewer parts, incremental computers have fewer failures and fewer malfunctions. (A malfunction is a temporary failure or "blooper.") In certain air-borne services, there might be 10 malfunctions and 1 failure per thousand hours of operation for the incremental computer, against 50 malfunctions and 5 failures for the conventional. (Again let us say that these numbers are estimates.) However, malfunctions are more devilish in incremental machines. They are difficult to correct because slewing time is so long. Moreover, the effects of all malfunctions carry over into future calculation in the incremental, whereas in the conventional most errors are wiped up in the next cycle of calculation. Accordingly, we estimate five serious malfunctions per thousand hours in the incremental, against two for the conventional. Adding up, it appears that two types have almost equal unreliability: Six or seven unsatisfactory performances per thousand hours are estimated. This is amazing, when we consider that the incremental has so many fewer parts.

Because they cannot handle large changes quickly, incrementals cannot do collating, sorting, and other forms of general information processing. This type of work has always been foreign to the real-time systems, but is now beginning to appear.

EVALUATION

When these characteristics are considered, it is clear that neither machine is uniquely the better. The ordinary incremental computer is good in simple jobs, where high bandwidth and small size are wanted, and where long slewing time can be tolerated. For example, it is good in an autopilot, or in guidance of a single-stage missile. It is not suitable where fast slewing or many decisions are needed, as in defensive fire control in a bomber or in the central computer of a complex weapons system.

The conventional machine is indicated wherever we have to have short slewing or the ability to implement decisions, or where several different calculations are to be done. It is indicated only if its larger size is not objectionable. This means that the machine is good in the large weapon-control problems.

One ought to note that a conventional computer is more flexible. Even after it is built, its function can be changed rather easily. This may be very useful. Often the final configuration of the system is not known at the time the computer is designed.

Hybrid machines, i.e., machines using both incremental and conventional structures in the same computer, are promising. Some have been built and are reported to have done well.

This ends our analysis. When a specific application comes along, the arguments should be weighed again. Our prediction is that the conventional design will be more and more used in air-borne real-time control.

Air Preheaters Installed

Duke Power Company expects to save about 10% on annual fuel costs for its new No. 5 boiler unit at Allen Plant, Belmont, N. C., with the installation of two Ljungstrom air preheaters. The preheaters, among the largest horizontal type ever built by the Air Preheater Corporation, Wellsville, N. Y., at rated load will recover about 390 F of heat which is normally wasted. It is estimated that for every 40 F of heat recovered, a resultant fuel reduction of 1% is realized. Weighing about 512,000 pounds each, the units will increase the efficiency of the new 1,800,000-pound-per-hour pulverized coal fired boiler. In the photograph below, the upper half of the rotor housing of a Ljungstrom air is shown being lowered into position.

Loss Measurement in Semiconductor Rectifier Equipment

I. K. DORTORT
MEMBER AIEE

IT HAS long been recognized that the efficiency of a large rectifier unit cannot be determined accurately by input–output power measurements. The "segregated loss" method has been written into rectifier standards because it reduces greatly the errors inherent in input–output measurements of high-efficiency equipments. However, when determining the losses of the semiconductor rectifier itself, we must take into account the difference of wave shape of the cell currents in normal operation and in the test circuit. The high incremental resistance of the cells precludes the direct equation of losses for the same average currents at different form factors.

The instantaneous forward voltage characteristic of a rectifier cell can be approximated by the linear equation

$$v = E_{th} + R_a i \tag{1}$$

from which it would be simple to compute the correction for form-factor. Use of this expression is hindered by the difficulty of evaluating the threshold voltage E_{th} and the incremental resistance term which should, in the practical case, include not only R_a but also the resistance of connections, cell fuses, balance reactors, etc.

If the ratio of the form factors in normal operation and on test is called K, and losses P_1 and P_2 are measured in the test circuit at I_d and KI_d respectively, then

$$P = \frac{K+1}{K} P_2 - KP_1 \tag{2}$$

The need for evaluation of E_{th} and R is avoided, and the test procedure itself does all the necessary averaging and factors in all resistances in the proper proportions. It is true that equation 2 is still based on a straight-line approximation, but P is in effect an interpolation between P_1 and P_2, which usually have a spread of only 15% to 20%. For 6-phase double-way and double-Y rectifiers, $K = 1.1$; for single-phase full-wave rectifiers, resistive load, $K = 1.0$; and for single-phase full-wave rectifiers, inductive load, $K = 0.9$.

Direct measurement of P_1 and P_2 may be unfeasible because of very heavy a-c buses and close-coupled equipments. Insertion of instrument transformers may be impracticable and modification of the buses for this purpose may change significantly both the I^2R and stray losses in this area. In any case, direct input measurements are generally not feasible for single-way rectifiers, especially in the heavy current ratings. It is often more expedient to measure the input power at the primary terminals of the rectifier transformer which will therefore include the transformer copper losses and a small portion of the iron loss. Since transformer losses must be subtracted before the application of equation 2 to obtain segregated rectifier losses, the rectifier transformer must be carefully calibrated.

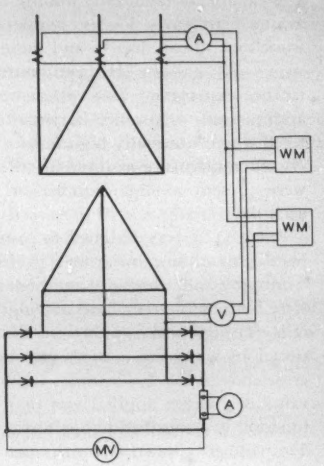

Fig. 1. Test circuit with primary current and secondary voltage instrumentation.

An ingenious test circuit was proposed at a meeting of the Joint AIEE Working Group on Semiconductor Rectifier Standards. This circuit, shown in Fig. 1, utilizes the rectifier transformer itself as an instrument current transformer. The voltage coils of the wattmeters are connected to the a-c terminals of the rectifier, thus avoiding the need for loss calibration of the rectifier transformer.

Loss measurements on the rectifier transformer primary side can be used without separate determination of the transformer losses, and substituted directly in equation 2, if we relax the requirement of segregation of rectifier losses and transformer copper losses. At the present time, standards require correction of transformer copper losses to a standard temperature. Without separate determination of losses this would be very difficult to do. It is suggested that specification of a minimum top oil temperature for the combined test, or similar device, will simplify testing and reduce the cost. Iron losses can be determined quite easily and added to the total loss for efficiency determination. We urge consideration of this method by all standardization bodies.

The test methods described have been applied to a wide variety of rectifiers with good results.

Digest of paper 61-23, "Proposed Method of Loss Measurement for Semiconductor Rectifier Equipments," recommended by the AIEE Semiconductor Rectifier and Industrial Power Rectifier Committees for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 29–Feb. 3, 1961. Scheduled for publication in AIEE *Applications and Industry*, July 1961.

I. K. Dortort is with the I-T-E Circuit Breaker Company, Philadelphia, Pa.

A Fatigue-Free Silicon Device Structure

W. B. GREEN

GERMANIUM DEVICES, when correctly used, are capable of essentially infinite life. It was commonly assumed in early higher temperature semiconductor work that silicon devices and those of other materials—such as SiC and the III-V compounds—would have similar life expectancy. However, among the early silicon applications, a number of installations were encountered where unusually high failure rates were recorded. A common feature of these installations was that there were present a large number of "off–on" operations each day.

A test cycle was designed to provide conditions comparable to those causing field problems. A high-current d-c supply and a high-voltage high-resistance d-c supply were both connected across a bridge of silicon rectifying cells. The current supply was alternately opened and closed by means of a cam-controlled timer. The time cycle chosen was 3½ minutes on, 6½ minutes off. The value of current applied was that necessary to heat a junction to a specified temperature in the time allowed. The voltage applied was such that its peak value was not greater than the peak inverse voltage of the cells. This test cycle has the advantage that if either the reverse voltage or thermal resistance of the cells deteriorates substantially, cell failure will occur. Failures did occur, and in an alarmingly small number of cycles. Typical of the results is that for a soft-soldered ⅝-inch-diameter junction, if the junction temperature reaches 180 C under load and cools to 35 C when not loaded, then an average of 1,200 load cycles will cause failure. By varying the junction temperature and junction diameter D (in inches) an empirical relationship was established:

$$ND^2\delta T^2 = C^2$$

where N is the number of cycles to failure, ΔT is the change in junction temperature in degrees C, and C is a constant, equal to about 3,500.

Careful attention was given to failures where both voltage and current were limited and where failed units were promptly removed from load to prevent overheating. These defective units all had a common characteristic, partial or complete fracture of one or both of the soft-soldered joints. When the fracture had progressed substantially through the solder joint, thermal resistance of the connection rose so as to allow the rectifying cell to fail because of excessive deterioration of reverse characteristics.

Thermal fatigue, such as is indicated here, arises when the soft solder is temperature cycled while in a state of plastic deformation. The plastic deformation is induced by the difference of thermal expansion coefficients of the silicon and copper case. Silicon has an expansion coefficient of about 4×10^{-6} inch per inch per degree C; for copper, it is about 18×10^{-6}. The silicon element, inherently brittle, must be protected from tensile and bending strains by being mounted on a rigid contact of a low-expansion coefficient metal, such as molybdenum or tungsten. In this form, the silicon can be soft soldered successfully to a copper case without strain on the silicon, but the soft solder is strained into a region of plastic deformation.

In principle, the deformation in the solder can be reduced by making the case of low-expansion material, but in practice, low-expansion materials have relatively high thermal resistances and are difficult to fabricate. In principle, too, the ΔT could be reduced but, in practice, if the junction temperature of a silicon cell is so reduced as to eliminate fatigue, then it has lost so much of its rating as to lose its economic usefulness as a rectifier.

The method chosen to solve this problem was to use a new type of hard-solder construction. The silicon is mounted on a thick contact of tungsten or molybdenum which, in turn, is joined with a hard solder to a pedestal of copper machined integral with the case. If the contact is sufficiently rigid, then the stress resulting from the difference of expansion coefficients causes strain primarily in the copper pedestal. This pedestal strain, while substantial, is only enough to cause elastic deformation; hence, no fatigue occurs. For small devices, connections may be made through thin copper or silver strips welded or brazed to molybdenum, tungsten, or tantalum contacts. A contact-to-strap-thickness ratio of 5 to 1 is satisfactory.

For connections of a cylindrical symmetry, a low-expansion ring is placed around the conductor, thus restricting its expansion so that it may be used directly as a contact.

This method of construction was first introduced in a ⅝-inch junction 250-ampere silicon rectifying cell. Tests on this cell were conducted under conditions where a soft-soldered cell would have first failures at 600 cycles and almost total failure by 2,000 cycles. A hard-soldered assembly has been subjected to more than 90,000 cycles under these conditions with no evidence of fatigue. In addition, thousands of cells of this type have been in service for periods up to 3 years with no fatigue failures yet recorded.

This same method of construction was recently introduced successfully also into 5- and 30-ampere silicon transistors and a 50-ampere silicon-controlled rectifier. Again, no fatigue failures have been observed.

Digest of paper 61-24, recommended by the AIEE Semiconductor Rectifiers Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Jan. 29–Feb. 3, 1961. Published in AIEE *Communication and Electronics*, May 1961, pp. 186-91.

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Thermoplastic Recording

A. SPENCER
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A new recording technique is described that is practically instantaneous, providing storage densities up to 40 million bits of information per square inch. Frequency response exceeds 40 mc and both image as well as sequential information can be recorded. Its versatility and practicality are illustrated by noting its broad field of application.

THERMOPLASTIC recording (TPR) is a new method for recording electrical signals which offers the processing speed and versatility of magnetic tape and the high storage capacity of photography. Even though it is still in the developmental stages, TPR already presents many advantages over both. Main advantages are:

(1) TPR is practically instantaneous and the tape this system uses requires no chemicals for its processing.

(2) Even at the present time TPR can store in a given area 100 to 150 times more information than magnetic tape and has the potential for far greater concentrations.

(3) The tape can record both images as well as sequential information rendering TPR useful for analog and digital computer applications.

(4) Stored information can be readily erased and the film reused many times.

(5) The frequency response of the system exceeds 40 mc, which is far beyond the requirements of even color video tape.

HOW IT WORKS

THE TPR technique employs an electron beam to produce deformations or "ripples" in the surface of a thermoplastic film. These ripples are detected by a special optical system and result in full color images or black-and-white images which can be either projected on a screen or converted to electrical signals by means of standard equipment such as flying-spot scanners or television camera pick-ups.

The tape used in TPR consists of three layers of plastic material: a base, made of a high melting plastic; a thin, transparent, conducting film; and a low-melting thermoplastic coating about 5 microns thick. (See Fig. 1).

A sharply focused electron beam deposits a charge pattern on the thermoplastic coating in accordance with the information to be stored. Since the thermoplastic is a poor conductor of electricity, the electrons will not be free to flow and leak away but will remain on the thermoplastic for a long period of time.

The film is then heated until the thermoplastic becomes liquid. The electrostatic charges deposited by the beam will be attracted toward the conducting layer, which acts as a ground plane, depressing the liquid at those points where the electrons are concentrated, thus causing ripples. Once the heat is allowed to dissipate to the surroundings, the thermoplastic becomes a solid again and the ripples are "frozen" in it. Thus, information has been stored.

The time required for the ripples to form depends on the viscosity of the liquid but is usually in the order of about 3 to 6 milliseconds.

To erase the film, the thermoplastic is made a good conductor to allow the electrons to leak away towards the ground plane. This is accomplished by heating it momentarily to a very high temperature. Once the electrons leak away, the surface tension of the liquid will smooth the top coating and, after the film has cooled and the thermoplastic has solidified, the tape is ready for reuse.

A practical way to furnish the heat necessary to process and erase the tape is by means of r-f heaters which confine intense heat to a small area. In this way, local erasure of portions about 5 mils square can be achieved to make correcting and editing just as simple as with magnetic tape. The r-f heaters consist of two bars, sepa-

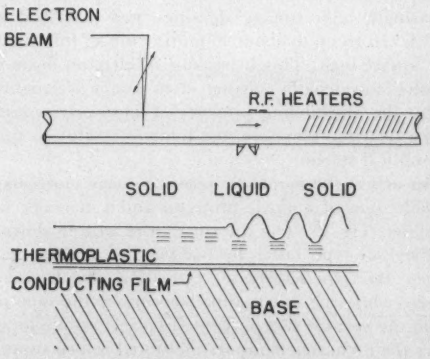

Fig. 1. Charges deposited by the electron beam deform the molten thermoplastic, producing ripples in its surface.

Essentially the full text of the student paper awarded the first prize in the 1959/60 competition of AIEE District 5. Recommended for publication by the AIEE Educational Publications Committee.

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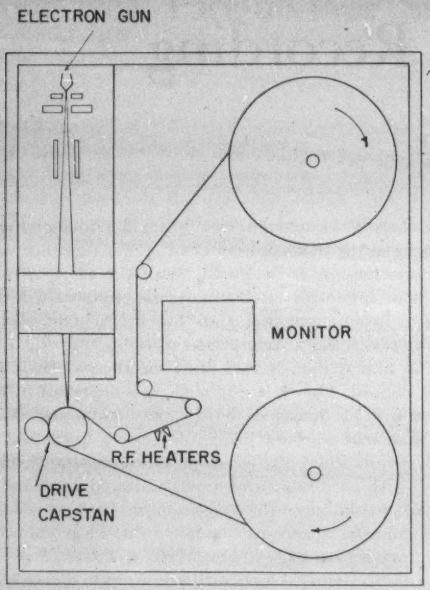

Fig. 2. Schematic diagram of the working model of a thermoplastic recorder.

rated by a small gap, that induce a high-frequency current in the conducting layer of the tape, thus heating the thermoplastic coating. The r-f field is applied for about 10 milliseconds which gives the ripples plenty of time to form.

Conceivably, then, the whole process of recording and storing information may take less than one hundredth of a second making it possible "to record all 24 volumes of the Encyclopedia Britannica on a reel the size of a spool of thread, taking only a minute to record each volume."[1]

The fact that an electron beam is used to write down the information to be stored is what gives TPR the amazingly high storage densities just described and which can go up to about 40 million bits of information per square inch: This is because an electron beam can resolve wavelengths smaller than the wavelength of light—the outstanding property of the electron microscope—leaving, therefore, the limit of resolution up to the optical system.

An actual thermoplastic recorder looks much like a combination of a movie projector and a magnetic tape recorder (Fig. 2). The information is written down in a television-type raster by making the electron beam sweep the tape crosswise, providing the horizontal sweep, while the longitudinal motion of the tape provides the vertical sweep. A small optical system located after the r-f heater monitors the stored information.

Due to the electron gun, the whole assembly is continuously pumped to produce the necessary vacuum.

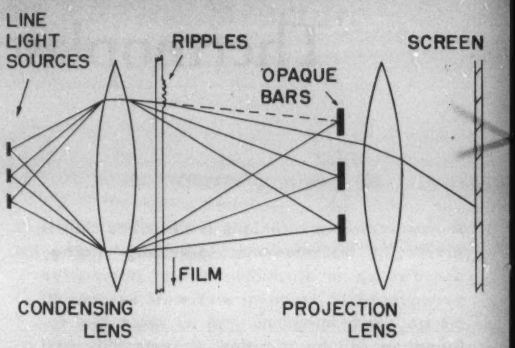

Fig. 3. The ripples on the surface of the film scatter light, producing a beam which shines through the slots and illuminates the screen.

This, however, is not too great a disadvantage because modern pumps supply very high vacuums in a very short time.

The inventor mentions that this system was tried in air by dragging a fine wire across the tape. However, the greater density, speed, and reproducibility of information available with the electron gun more than compensate for the extra equipment required for the vacuum.

READING STORED INFORMATION

THE INFORMATION STORED in the form of ripples is read by means of an optical system which makes use of the principles of phase diffraction gratings.

Basically, light passing through a smooth film travels in a straight line. But if the surface of the film is not smooth and contains a set of fine lines or ripples, light is bent or scattered at different angles. For this reason, the TPR projector has line-light sources—in contrast with the homogeneous light sources of opaque bars placed in front of the projection lens. In this way, no light appears on the screen since it is stopped by the opaque bars (Fig. 3).

If the film is inserted between the condensing lens and the opaque bars, the ripples in its surface will bend

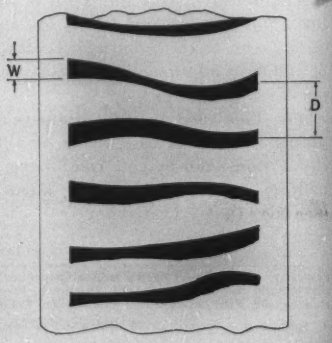

Fig. 4. This is a view through the film as seen by the light sources. *W*, the width of the ripples, changes the intensity of the images; *D*, the distance between ripples, changes the color of the image.

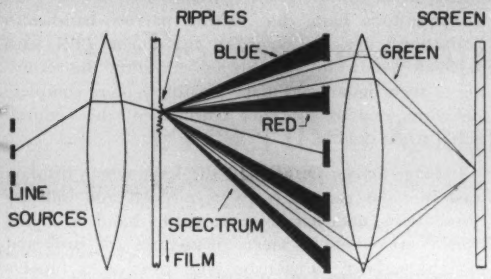

Fig. 5. The ripples in the film scatter light into the color spectrum. The slots allow only one color to fall on the screen.

or scatter the light shining through it so that some light beams will shine through the slots between the bars and the screen will be illuminated. Thus, the bar system acts somewhat like a shutter which allows a bright spot to appear on the screen whenever there is ripple on the film and a dark spot when the film is perfectly smooth.

The intensity of the spot appearing on the screen depends on the width of the ripple so that the wider the ripple the brighter the spot and the thinner the ripple the darker the spot (Fig. 4). Consequently, all shades of gray can be obtained by simply varying the width of the ripple, a variation easily obtained by proper control of the electron beam as will be shown later.

The aforementioned projector can take, for instance, a clear slide that has the proper set of ripples in its surface and it will be projected on the screen as a high quality black-and-white picture. To view this slide it is not necessary to use a special projector because by shining light at an angle the pictures become clear to the naked eye.

COLOR INFORMATION

THE IDEA behind color information storage is that a set of ripples which are close together form a diffraction grating. This diffraction grating acts somewhat like a prism in that it scatters light into the color spectrum in a similar way to that encountered when looking at the microgrooves of a long-playing record at an angle. However, instead of producing just one spectrum like a prism, the grating forms various spectrums and on both sides of the central beam. The central beam is the one which occurs when the film is perfectly smooth.

The opaque bars and the slots are arranged in this case so that the bars stop the whole spectrum while the slots allow only one color to pass through. Consequently, an area containing a suitable grating will appear on the screen in one color (Fig. 5).

The angle by which the spectrum is deviated from the central beam depends on the spacing between adjacent ripples (Fig. 4). If this distance is small, the spectrum is deviated by a large angle while the opposite is true if the distance between the ripples is large. To make the spot appear in a different color, the spacing of the ripples is changed to place a different portion of the spectrum on the slots. Colors which are the combination of two others can be obtained by superimposing the ripples corresponding to the individual components.

Summarizing, the information is stored and read in terms of the *width* of the ripples and the *spacing* between the ripples.

WRITING INFORMATION

AS DESCRIBED in a previous section, light intensity is read in terms of the width of the corresponding ripples. To write information of this kind, the intensity of the electron beam is modulated because the action of the electrons deposited on the thermoplastic surface is similar to a wedge. When more electrons are deposited on the film the increased electrostatic forces make the electrons press deeper into the melted thermoplastic and, due to the viscosity of the liquid, the ripple becomes wider. Therefore, the electron-beam intensity is made proportional to the light intensity desired.

The input signal required can be obtained from the intermediate frequency signal of a black-and-white television set at about a 1-volt level and is directly applied to the intensity control grid of the electron gun.

To write color information, the spacing between the ripples should be varied. To accomplish this, the electron beam is first split into two, three or five beams. Then, as these beams pass between two plates denoted as modulator electrodes (Fig. 6), a suitable potential is applied either to separate the beams from one another or bring them closer together. Thus, an electron gun producing a split beam is capable of storing all the necessary information for a good reproduction of color pictures since both beam intensity and beam separation can be modulated, resulting in both color and brightness variations.

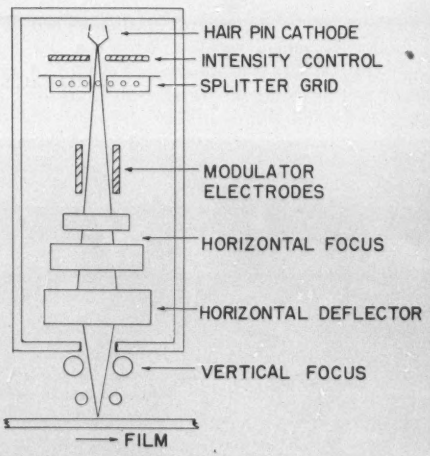

Fig. 6. Cut-away view of the electron gun used with the thermoplastic recorder.

APPLICATIONS

1. *Video Tape.* TPR is expected to replace magnetic video tape recording in most cases or complement it in others. Magnetic tape must run at 60 inches per second for this particular application and is subject to great friction and wear due to the high-contact pressure it requires with the magnetic head. TPR tape, on the other hand, stores just as much or even more information while it is running at 5 inches per second. Friction and wear are minimal so that TPR tape should greatly outlast magnetic tape.

The life-like characteristics of magnetic video tape recordings can be obtained and surpassed with TPR because it has the resolution capabilities of live broadcasts and proper compensation (gamma correction) can be made on the film to produce this subjective impression.

The present dynamic range of TPR, that is, the ratio of the maximum to the minimum signal which can be recorded with a prescribed amount of distortion, is comparable to the dynamic range of average magnetic tape recordings. The range is limited by the cleanliness of the film base, which gives grounds for further improvements.

2. *Aerial Reconnaissance.* TPR is specially fitted for aerial reconnaissance because it provides immediate monitoring of the recorded data. Thus, the quality and value of the pictures can be known right away and retakes can be made immediately if necessary. Also, since the pictures are readly within fractions of a second, the information can be distributed without delay.

3. *Radar Jamming and Countermeasures.* The analysis of intercepted radar signals has been difficult and complex, requiring a relatively large amount of equipment, and these signals have never been recorded on a continuous basis due to the narrow bandwidth limitations of present recording equipment. TPR, with its 50-mc bandwidth capabilities, will allow the recording of such signals and make possible a more complete spectrum analysis for later synthesis of the counter-signal when desired.

4. *Large Screen Display.* In the large screen displays used in radar control rooms at airports and military installations, data has been plotted by hand or copied from radar screens by means of pictures and projected some time later. Obviously, both procedures involve precious time lost as well as a possibility of errors. TPR, however, copies the radar signal and offers it immediately for projection with no loss in detail or quality.

5. *Microfilm.* The high storage densities available with TPR should make it possible to store entire libraries in equipment considerably smaller than the one used for photographic microfilm.

Many other applications are envisioned for thermoplastic recording as in: time compression techniques (speeding up slow-occurring events), integrated displays (simultaneous view of various sources of information), missile guidance and satellites.

As far as the home is concerned, it is still too early to say, but it seems likely that once TPR is perfected there may be movie cameras which will permit taking pictures, seeing them right away, retaking whichever shots did not come out, and reusing old films.

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Univac's 10th Birthday

The 10th birthday of the first commercial electronic computer, Unival *1*, serial *1*, was observed recently at the Census Bureau. Shown looking at the computer are Secretary of Commerce Luther H. Hodges *(right)*, J. Presper Eckert *(left)*, co-inventor and vice-president of Remington Rand Univac, and Miss Elizabeth North *(center)*, one of the original Univac Census Bureau operators. Since first going into operation March 31, 1951, it is estimated that the "brain" has performed more than 510 billion basic arithmetic operations. A second Univac *1* and two Remington Rand Univac *1105* computers have been purchased and placed in service by the Bureau, since the first machine was installed, to handle the ever increasing load of data concerning the nation's population.

Transistor Amplifier Stages with Prescribed Gain and Sensitivity

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The problem of designing transistor amplifier bias circuits is one of resolving conflicting requirements of operating-point stability, gain, and gain sensitivity. In this article, a procedure is developed which permits the solution of the amplifier design problem by means of an orderly sequence of calculations.

THE MANY and varied aspects of transistor amplifier sensitivity to changes in temperature and transistor unit replacement have received considerable attention in the literature. Numerous investigations have been reported pertaining to the thermal displacement of the transistor operating point and the variation of its incremental parameters with the shift of the operating point and with temperature.[1-13] Further, various schemes for stabilizing the operating point have been considered in detail,[3,6,9-15] and design procedures for specific as well as generalized bias network configurations to effect this stabilization have been proposed.[3,6,13,14,16]

It should be recognized that the design of linear bias circuits is not affected by the origin of the variations against which stabilization must be maintained; indeed, the unit-to-unit differences encountered in transistor parameters and static characteristics frequently dwarf the corresponding variations resulting from temperature changes. It also will be noted that the magnitude and sensitivity of the incremental gain of the amplifier are functions of the bias network parameters as well as those factors which give rise to the need for operating point stabilization. Clearly, the interdependence of bias stabilization, gain, and gain stabilization would appear to indicate the desirability of an approach to the design problem based upon the simultaneous satisfaction of these (as well as additional) constraints. However, the various treatments accorded the problem in presently available literature do not provide the circuit designer with an orderly procedure for including all of these constraints on the basis noted.

It is the purpose of this article to develop a procedure for effecting a design to meet prescribed gain and sensitivity criteria in terms of anticipated operational variations and such device data as are readily available from manufacturers' specifications. The amplifier prototype considered herein corresponds to the frequently encountered configuration shown in Fig. 1. The particular problem faced by the designer is that of specifying R_1, R_2, R_C, and R_E so that the displacement of the operating point (expressed most conveniently as a change in collector current) and the deviation of the incremental gain from a design center value are held within prescribed limits, despite unit-to-unit variations and temperature effects. Furthermore, the design must be such that any incompatabilities between the gain and stability requirements on the one hand and the system constraints on the other (i.e., source and load impedances for the amplifier and direct voltage supplies) are resolved.

THEORETICAL CONSIDERATIONS

Stabilization of Operating Point. As already stated, it is of considerable practical importance to limit the change in collector current that takes place as a result of variation in temperature and unit-to-unit differences in transistor static characteristics. The changes that actually occur depend, of course, not only on the transistor volt–ampere relations, but also on the properties of the network in which the device is embedded. It is of interest to consider in detail the properties of the circuit composed of transistor and associated networks.

In order to simplify the analysis of the amplifier in Fig. 1, the base circuit voltage divider, R_1, R_2, is replaced by its Thévenin equivalent, R_B, E_{BB}, in Fig. 2. The elements of the complete amplifier of Fig. 2 which are of interest for d-c conditions are shown in Fig. 3(a). The conclusions to be drawn for this circuit will also

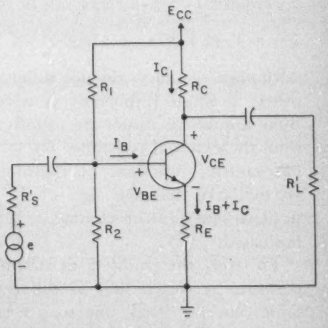

Fig. 1. Common-emitter transistor amplifier with bias network.

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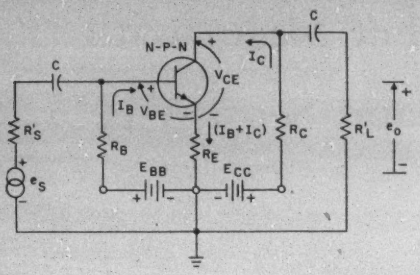

Fig. 2. Transistor amplifier with bias network replaced by Thévenin network.

apply with slight modification to certain other bias arrangements commonly used. The bias scheme shown in Fig. 3(b), for example, can be shown to be equivalent to that in Fig. 3(a).

The various currents and voltages indicated in Fig. 3(a) may be related to one another by the two Kirchhoff voltage law equations:

$$E_{BB} = R_E I_C + (R_E + R_B)\, I_B + V_{BE} \tag{1}$$

$$E_{CC} = (R_E + R_C)\, I_C + R_E\, I_B + V_{CE} \tag{2}$$

Naturally, to find a unique solution for I_B and I_C, the characteristics must be introduced by furnishing information concerning the variation of V_{BE} and V_{CE} as functions of I_B and I_C.

Fig. 4 depicts the V_{CE}–I_C family as a function of base current for two different temperatures. It may be noted that if base current is held constant, the collector current increases as temperature increases. As a result, if one desired to keep the collector current fixed as the temperature increased, it would be necessary to decrease the base current.

The base-to-emitter volt–ampere characteristics also change with temperature. Representative curves illustrating the variation are shown in Fig. 5. At temperature T_1 the relation between V_{BE} and I_B can be expressed as

$$V_{BE} = V_{BE_1} + r_1 I_B \tag{3}$$

where r_1, the d-c resistance of the forward-biased junction, is a function of I_B. As the temperature changes to T_2 (where $T_2 > T_1$), there can be written similarly

$$V_{BE} = V_{BE_1} + \Delta V_{BE} + r_2 I_B \tag{4}$$

Although r_1 and r_2 do not differ greatly from one another, a more important consideration here is that their numerical values are usually considerably smaller than the external resistance $R_B + R_E$ in series with the base-emitter junction. Furthermore, it is to be noted particularly that the sign of ΔV_{BE} is negative for a positive temperature change, i.e., V_{BE} decreases as T is increased.

To study the problem of stabilizing I_C both as temperature is varied and as different transistors of the same type are used, one may treat the characteristics at T_1 and T_2 in Figs. 4 and 5 as representing the extreme variations due to all causes for which suitable compensation is to be provided. In terms of changes in I_C and I_B, the use of equations 3 and 4 in conjunction with equation 1 provides the expression

$$(R_B + R_E)\, \Delta I_B + R_E \Delta I_C = -\Delta V_{BE} \tag{5}$$

In formulating this result, r_1 and r_2 have been neglected compared with $R_B + R_E$. The sign of ΔV_{BE} is negative for a positive temperature change. Furthermore, if $R_E I_B$ is small compared with $(R_E + R_C)\, I_C$, which is usually true, then a good approximation to equation 2 is

$$E_{CC} = (R_E + R_C)\, I_C + V_{CE} \tag{6}$$

This is the familiar load-line equation, a typical construction of which is shown in Fig. 4. Since the locus of all possible operating points (V_{CE}–I_C pairs) must be on the load line, the quiescent point and the new operating point after change in transistor characteristics must both be located on this line.

Let us assume that the desired quiescent point Q (V_{CE}, I_C), the collector supply voltage (E_{CC}), and the maximum change in collector current (ΔI_C) are specified. From this information, as suggested by Fig. 4, one may determine at once the base current I_{B1} needed to provide Q as well as the quantity $\Delta I_B = I_{B2} - I_{B1}$, the change in base current needed to insure that I_C goes to $I_C + \Delta I_C$. It may be determined from Fig. 4 that for small values of positive ΔI_C (resulting essentially in a constant I_C), the required ΔI_B has a negative sign.

In order that the design objective of ΔI_C may be realized, circuit elements external to the transistor must be chosen to insure that the necessary change in I_B does in fact occur. Considering equation 5, it is evident that R_B and R_E must be selected to have values which insure that when ΔV_{EB} changes, ΔI_B can assume the proper negative value corresponding to ΔI_C. It is necessary that

$$\left(1 + \frac{R_B}{R_E}\right) \Delta I_B = -\frac{\Delta V_{BE}}{R_E} - \Delta I_C \tag{7}$$

Recall that the sign of ΔV_{BE} is negative and that the sign of ΔI_B must also be negative in the problem of immediate interest here. On the other hand, the sign of ΔI_C is positive for a positive temperature change. It is clear then that R_E must have a certain minimum value in order that a negative ΔI_B may be obtained.

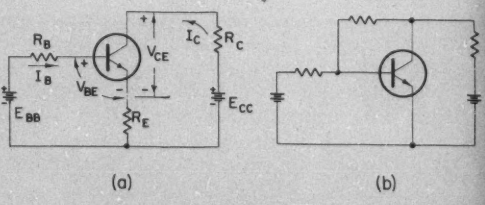

Fig. 3. (a) Portion of transistor amplifier pertinent to d-c analysis. (b) Transistor amplifier with alternative bias network.

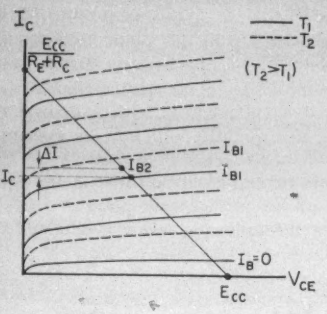

Fig. 4. Shift of collector family as a function of temperature.

The smallest value of R_E that will insure a given negative ΔI_B in equation 7 is determined by setting $R_B = 0$; it is then found that

$$R_{E\min} = -\frac{\Delta V_{BE}}{\Delta I_C + \Delta I_B} \tag{8}$$

For $R_B \neq 0$, the value of R_E necessary to satisfy equation 7 is given by

$$R_E = R_{E\min}\left(1 + R_B \frac{\Delta I_B}{\Delta V_{BE}}\right) \tag{9}$$

Merely specifying the quiescent point, ΔI_C, and E_{CC} does not provide sufficient information to determine R_B and R_E uniquely. One may specify sensitivity to a-c gain changes in addition to the d-c information and solve for R_B and R_E. Certain relations are implied, however, when just the d-c data are given, and it is of interest to examine some of these before turning to the questions of a-c sensitivity and voltage gain. From equation 8, it is clear that the information regarding the operating point and its shift fixes a minimum value of R_E. With the quiescent point specified, the voltage drop across R_E at the initial temperature is $R_{E\min}(I_C + I_{B1})$. As a consequence, the maximum value of R_C that may be used is already fixed at the value

$$R_{C\max} = \frac{E_{CC} - V_{CE}}{I_C} - R_{E\min}\left(1 + \frac{I_{B1}}{I_C}\right) \tag{10}$$

In general, R_C is related to R_E as

$$R_C = R_O - R_E \tag{11}$$

where

$$R_O = \frac{E_{CC} - V_{CE}}{I_C} \tag{12}$$

and I_{B1}/I_C has been assumed small compared to unity. Since the a-c load impedance for the amplifier is the parallel combination of R_L' and R_C (neglecting the effect of C_2), specification of operating-point data and d-c shift is seen to have an important effect on the voltage gain that can be realized from the stage. Furthermore, since it is seen from Fig. 2 that R_B shunts the a-c signal transmission path, it will not be practical to choose $R_B = 0$ (which resulted in the $R_{E\min}$ given by equation 8). It will be seen in the next section that R_B also affects the sensitivity to gain change. The design problem that must be considered, of course, is the choice of R_B, R_C, and R_E, in order that a suitable compromise may be made among d-c stabilization, a-c sensitivity, and voltage gain.

Provision of A-C Sensitivity. In terms of the quantities shown in Figs. 1 and 2, the voltage gain of the amplifier stage is defined as

$$G_v = \frac{e_o}{e_s}$$

It may be shown that G_v is given approximately by

$$G_v \doteq \frac{R_B}{R_s' + R_B} \frac{R_L}{R_E + r_e + (R_s + r_b)\left(\frac{1}{b} + \frac{R_E + r_e + R_L}{r_c}\right)} \tag{13}$$

where

$$R_s = \frac{R_s'\, R_B}{R_s' + R_B} \quad \text{and} \quad R_L = \frac{R_L'\, R_c}{R_L' + R_c} \tag{14}$$

and r_e, r_b, r_c, and b are the usual small signal transistor parameters. If it is assumed that b changes to $b + \Delta b$ with the other small signal parameters remaining essentially constant in the process, then the fractional change in gain can be written

$$\frac{\Delta G_v}{G_v} \doteq \frac{\Delta b}{b} \frac{1}{1 + (b+\Delta b)\dfrac{(R_E + r_e)}{R_E + r_e + r_b + R_s}} \tag{15}$$

In the derivation of equations 13 and 15, it has been assumed that $b \gg 1$, $r_e \ll r_c(1-a)$, $r_c \gg r_e + R_E + R_L$, and $r_c \gg r_e + R_E + R_S + r_b$. Equation 15 may be expressed in the form

$$\frac{\Delta G_v}{G_v} = S\,\frac{\Delta b}{b} \tag{16}$$

where S, the sensitivity function frequently used in feedback theory, is related to the circuit parameters by

$$\frac{1}{S} = 1 + (b+\Delta b)\frac{(R_E + r_e)}{R_E + r_e + r_b + R_s} \tag{17}$$

As may be seen from equation 16, in order to minimize the percentage change in voltage gain for a prescribed percentage change in b, one should strive to make S as

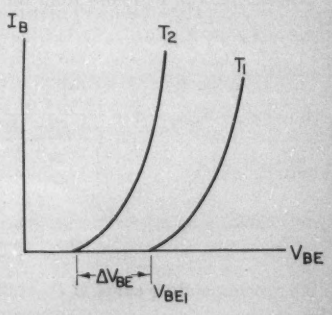

Fig. 5. Shift of emitter-base characteristic as a function of temperature.

small as possible. If the requirements on R_E imposed by the d-c stabilization conditions as expressed by equations 8 and 9 are combined with equation 17, the sensitivity can be written in terms of R_B as

$$1/S = 1 + (b+\Delta b)\,\frac{R_{E\min} + kR_B + r_e}{R_{E\min} + kR_B + r_e + r_b + \dfrac{R_s'\,R_B}{R_s' + R_B}} \tag{18}$$

where

$$1/k = -\left(\frac{\Delta I_C}{\Delta I_B} + 1\right) \tag{19}$$

Equation 18 indicates that the sensitivity is a monotonic function of R_B for positive values of R_B. S attains its maximum value when $R_B = 0$ and a minimum value, as R_B becomes infinitely large, of

$$S = \frac{1}{1 + b + \Delta b}$$

It follows from equations 9 and 11 that R_B cannot be increased indefinitely since, with a prescribed E_{CC}, there is an upper limit for R_E, and hence R_B, beyond which it is not possible to attain the desired quiescent point. The upper limit is evident from equation 11, as being $R_E = R_O$, at which condition G_v has the value zero because $R_C = 0$. As a consequence, once the d-c operating point, supply voltage, and shift in collector current, together with the transistor characteristics, are specified, one is limited to a sensitivity S whose values lie between fixed limits. The maximum sensitivity attainable is

$$S_{\max} = \frac{1}{1 + \dfrac{(b+\Delta b)\;(R_{E\min} + r_e)}{R_{E\min} + r_e + r_b}} \tag{20}$$

whereas the minimum is

$$S_{\min} = \frac{1}{1 + \dfrac{(b+\Delta b)\;(R_O + r_e)}{R_O + r_e + r_b + R}} \tag{21}$$

where R is the parallel combination of R_S' and a resistance of value $(R_O - R_{E\min})/k$ ohms. It is to be noted that equations 20 and 21 represent limits of an achievable sensitivity range, since $G_v = 0$ at each extreme.

If in addition to stipulating the d-c stabilization conditions a sensitivity S between the limits of equations 20 and 21 is selected, the necessary value of R_E to achieve this can be found from the equation

$$R_E^2 + A_1 R_E + A_0 = 0 \tag{22}$$

where

$$A_1 = k\,R_s' - R_{e\min} + r_e + \frac{(R_s' + r_b)}{1 - \dfrac{S(b+\Delta b)}{1 - S}} \tag{23}$$

and

$$A_0 = r_e(kR_s' - R_{E\min}) + \frac{r_b\,k\,R_s' - (R_s' + r_b)\,R_{E\min}}{1 - \dfrac{S\,(b\;+\Delta b)}{1 - S}} \tag{24}$$

The corresponding value of R_B is then

$$R_B = (R_E - R_{E\min})/k \tag{25}$$

Gain Requirements. Up to this point attention has been concentrated on achieving both d-c and a-c sensitivity. In a practical design, of course, these sensitivities must be achieved simultaneously with a desired G_v. Factors affecting this quantity will now be examined in detail.

If equations 11, 14, and 25 are utilized in the equation 13 for G_v with the further assumption that $(R_E + r_e + R_L)/r_c \ll 1/b$, the following result is obtained for the voltage gain:

$$G_v = \frac{(R_O - R_E)}{(R_L' + R_O - R_E)} \times \frac{R_L'\,(R_E - R_{E\min})}{(R_E + r_e + r_b/b)\,(kR_s' + R_E - R_{E\min}) + \dfrac{R_s'}{b}\,(R_E - R_{E\min})} \tag{26}$$

Although it is desirable to study the variation of G_v with R_E in a direct fashion, a suitable understanding of the variation can be obtained with considerable saving in algebraic manipulation by an indirect approach. The first ratio in this equation is the fraction of the collector signal current that is supplied to R_L'. In the region of interest here, $R_E < R_O$, this factor is seen to decrease monotonically as R_E increases. The second ratio in G_v rises from zero to a maximum and then decreases, finally approaching zero as R_E is continuously increased, starting from $R_{E\min}$. This second factor, to be identified as G_{1v}, can be studied conveniently by using $R_E - R_{E\min}$ as the independent variable rather than R_E. It is readily found that the maximum value of G_{1v} occurs when $R_E = R_{E\min} + R_m$, where

$$R_m = \sqrt{kR_s'(r_e + R_{E\min} + r_b/b)} \tag{27}$$

The maximum value of the second factor at this value of R_E is

$$G_{1v\max} = \frac{bR_L'}{R_s' + \left[\sqrt{bkR_s'} + \sqrt{b(r_e + R_{E\min})} + r_b\right]^2} \tag{28}$$

Because of the monotonic nature of the first ratio in G_v, the maximum value of G_v will occur at a smaller value of R_E than $R_{E\min} + R_m$, and thus it is evident that if $R_O > R_{E\min} + R_m$,

$$G_{v\max} > G = \frac{(R_O - R_{E\min} - R_m)}{(R_L' + R_O - R_{E\min} - R_m)} \times \frac{bR_L'}{R_s' + \left[\sqrt{bkR_s'} + \sqrt{b(r_e + R_{E\min})} + r_b\right]^2} \tag{29}$$

Equation 29 is of importance in the amplifier design procedure because it permits an estimate to be made of the feasibility of achieving a desired G_v while simultaneously having a required sensitivity S. If the desired G_v is equal to or less than the G given by equation 29, than the value of R_m which will yield the desired G_v may be determined by the use of the equation

$$x^3 - B_2x^2 - B_1x - B_0 = 0 \tag{30}$$

in which

$$B_0 = kR_s' (R_L' + R_O - R_{E\min}) (r_e + R_{E\min} + r_b/b) \quad (31)$$

$$B_1 = (r_e + R_{E\min} + r_b/b) (R_L' + R_O - R_{E\min} - kR_s') + (1+k) R_s' R_L' - (R_O - R_{E\min}) [(1+k) R_s' + R_L'/G_v] \quad (32)$$

$$B_2 = R_L' (1 + 1/G_v) + R_O - (1+k) R_s' - r_e - 2R_{E\min} - r_b/b \quad (33)$$

and the variable x is $R_E - R_{E\min}$. The equation was obtained by solving equation 26 for $R_E - R_{E\min}$.

Now that a sufficient theoretical background has been established, it is possible to describe a comparatively direct design procedure for determining the unknown elements in the amplifier of Fig. 1. It is helpful to define the design problem again in the light of the results that have been obtained. Given the quiescent operating point V_{CE}, I_C, the permissible shift in collector current (ΔI_C), the collector supply voltage E_{CC}, the normal and modified (by temperature change or substitution of unit) transistor characteristics, and the terminating resistances R_s' and R_L', it is desired to determine R_E, R_C, R_1, and R_2 (in the circuit of Fig. 1) in order to provide a desired voltage gain G_v and fractional change in gain $\Delta G_v/G_v$. Both of these requirements cannot be satisfied exactly, in general, but instead one requirement will be met with some design margin whereas the other will be just satisfied. There are not enough degrees of freedom to satisfy both exactly. For design convenience, the requirement on fractional gain change is reduced to the specification of a sensitivity S by the use of equation 16.

The design procedure suggested here assigns first priority to achieving, but not exceeding, the permissible shift in collector current ΔI_C. This position is taken because it is an important practical consideration that effective stabilization of d-c collector current is a first requisite in the control of amplifier performance in the presence of temperature variation and unit-to-unit variations. Starting with E_{CC}, (V_{CE},I_C), and ΔI_C, ΔI_B can be determined from the collector family and ΔV_{BE} from the device data. It is then possible to compute the quantities k, $R_{E\min}$, and R_O using equations 19, 8, and 12. The limits of achievable sensitivity S may then be determined by use of equations 20 and 21, and an estimate of the attainable voltage gain G_v may be made by use of equation 29. When the last three results have been obtained, the designer is able to assess the compatibility of the design requirements. If the desired G_v is less than G of equation 29 and the desired sensitivity is greater than that computed from equation 21, it is appropriate to proceed to the determination of R_E and the other elements. If these conditions are not met, either the design requirements must be modified or a different type transistor selected. However, some additional compromise in the requirements on G_v and S may still be necessary. Knowing that the desired G_v and S may be achieved in the range of values permitted for R_E, the designer may use either equation 22 or 30 to find the exact value of R_E required to satisfy the specification on one quantity. Normally the first of these two equations is more desirable to use because it is a quadratic, as compared to the cubic equation 30. In the range of circuit values commonly encountered, however, equation 30 frequently can be approximated by reduction to a quadratic equation as well. If R_E has been determined on the basis of the requirement on S (using equation 22), it is necessary to check the corresponding value of G_v using equation 26. If the value obtained is less than required, one must decide whether the S or the G_v requirement will take precedence in the design. The final value of R_E is selected after this decision has been made. Finally, R_B and R_C are determined using equations 25 and 11, respectively.

In order to specify the elements R_1 and R_2 in Fig. 1, it is necessary to use the values of R_E and R_B determined in equation 1 with values of I_C, I_B, V_{BE}, and V_{CE} at the quiescent point in order to determine E_{BB}. The values of R_1 and R_2 may then be found from

$$R_1 = R_B E_{CC}/E_{BB} \quad (34)$$

$$R_2 = R_B/(1 - E_{BB}/E_{CC}) \quad (35)$$

One other aspect of design is worth noting in connection with the circuit. If the quantity E_{CC} is not considered to be fixed, but instead is treated as a design parameter, then additional design freedom may be obtained. If the quiescent operating point is chosen in a region of the collector family where the curves are essentially parallel, then the change in base current, ΔI_B, for a desired ΔI_C can be estimated quite accurately without benefit of the load line, which is established as soon as V_{CE}, I_C, and E_{CC} are specified. If E_{CC} is not specified, then R_O as given by equation 12 is not fixed and may be treated as an additional design parameter. In particular, if there is difficulty in meeting the gain requirement, it may be seen from equation 29 that a sufficiently large increase in R_O can cause G to approach the G_{1v} given by equation 28. In addition, if a sufficiently large R_O can be achieved, the minimum sensitivity given by equation 21 may be made to approach the value wherein R is replaced by R_S'.

Design examples in the next section illustrate some of the procedures just discussed.

ILLUSTRATIVE EXAMPLES

THE USE of the design techniques discussed here may be readily demonstrated by means of the following specific examples:

1. An amplifier is to be designed to operate between a source impedance of 200 ohms and a load impedance of 2,500 ohms in a system provided with a 35-volt d-c power supply. The voltage gain is required to be not less than 3 and must be held constant within 10% of the value ultimately selected for the nominal gain. The transistor employed in the design is operated (nominally) at a quiescent point such that $V_{CE} = 9$ volts, $I_C = 7$ milliamperes, $V_{BE} = 0.7$ volt, $I_B = 0.4$ milliampere, and it is stipulated that the collector-current variation must be limited to 2 milliamperes.

The collector characteristics and device data indicate that an estimate of 0.25 milliampere for ΔI_B is appropriate and that a ΔV_{BE} of 0.2 volt should be allowed for. The small signal transistor parameters are $r_e = 5$

ohms, $r_b = 200$ ohms, and the range of b to be tolerated is 20–80 (so that $b = 20$, $\Delta b = 60$). Since the $\Delta G_v/G_v$ must be less than 10% and since a $\Delta b/b$ of 3 must be tolerated, the sensitivity required is 3.3%. The design proceeds as follows:

From equation 19, $k = 1/7$
From equation 8, $R_{E\min} = 114$ ohms
From equation 12, $R_O = 3{,}710$ ohms
From equation 20, $S_{\max} = 3.25\%$
From equation 21, $S_{\min} = 1.37\%$
From equation 27, $R_m = 60.8$ ohms, which is less than $R_O - R_{E\min}$
From equation 29, $G_{v\max} > 5.06$

Clearly, the sensitivity and gain requirements of the amplifier lie within the limitations noted, so that the design may be completed. Since the $\Delta G/G$ required is less stringent than that which may be realized for $R_E = R_{E\min}$, specifying a design value of $S = 3\%$ is not unreasonable, whence

From equation 22, $R_E = 242$ ohms
From equation 25, $R_B = 426$ ohms
From equation 11, $R_C = 3{,}468$ ohms
From equation 1, $E_{BB} = 2.66$ volts
From equation 34, $R_1 = 5{,}600$ ohms
From equation 35, $R_2 = 462$ ohms

The resistors to be used in the amplifier may now be designated (using standard values) as follows: $R_E = 240$ ohms, $R_C = 3{,}300$ ohms, $R_1 = 5{,}600$ ohms, $R_2 = 470$ ohms. Finally, the values for G_v and $\Delta G_v/G_v$ using the designated resistors are, from equations 13 and 15, respectively, $G_v = 3.7$ and $\Delta G_v/G_v = 8.65\%$ (or $S = 2.88\%$).

2. Suppose that the sensitivity requirement for the amplifier discussed above is to be changed so that $S = 2\%$, with the remaining specifications to be met as stated. If the design procedure is followed as previously, it is found that

From equation 22, $R_E = 605$ ohms
From equation 25, $R_B = 3{,}437$ ohms
From equation 11, $R_C = 3{,}105$ ohms

On the basis of these values, it is found from equation 26 that the resulting gain is only 2.07, as compared with the amplifier specification of 3. Since k, $R_{E\min}$, and R_E are fixed by operating point and gain sensitivity requirements, the design freedom obtained by treating R_O as an additional parameter becomes strikingly apparent from an examination of equation 26 for the values of k, $R_{E\min}$, and R_E applicable herein:

$$G_v = \frac{R_O - 605}{R_O + 1{,}895} \quad (3.75)$$

It is readily established from this relation that a voltage gain of 3 may be obtained for an R_O of 10,615 ohms; this requires, from equation 12, a d-c supply voltage $E_{CC} = 83$ volts. If this supply-voltage requirement can be accommodated, the design may proceed, as in the previous example:

From equation 11, $R_C = 10{,}010$ ohms
From equation 1, $E_{BB} = 6.55$ volts
From equation 34, $R_1 = 43.5$ kilohms
From equation 35, $R_2 = 3{,}730$ ohms

The resistors to be used in the amplifier may now be designated (using standard values) as follows: $R_E = 260$ ohms, $R_C = 10$ kilohms, $R_1 = 43$ kilohms, $R_2 = 3.6$ kilohms.

Finally, the values for G_v and $\Delta G_v/G_v$ using the designated resistors are, from equations 13 and 15, respectively, $G_v = 2.95$ and $\Delta G_v/G_v = 5.96\%$ (or $S = 1.99\%$).

CONCLUSIONS

THE PROBLEM of designing bias circuits for transistor amplifiers is one of resolving conflicting requirements of operating-point stability, gain, and sensitivity, while taking into account specific system constraints and substantial variations in the device characteristic. The design procedure developed in this article permits the solution of the amplifier design problem by means of an orderly sequence of calculations. The procedure also indicates readily when the given performance requirements are mutually incompatible, i.e., when a solution to the design problem cannot be obtained in the presence of the constraints imposed.

The results of the analysis also indicate that an additional design facility may be acquired by allowing a particular factor normally considered to be a system constraint, such as the supply voltage, to be treated as an additional design parameter. The possibility of utilizing the additional design freedom becomes strikingly apparent as one employs the design procedure presented.

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Experiments on a Series of S-Band Crestatrons

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IN recent years power klystrons, traveling-wave amplifiers and various forms of crossed-field amplifiers and oscillators have been produced in relatively large numbers with essentially reproducible characteristics. Gradually, these devices have found their way into more and more sophisticated systems applications with the logical result that they are competing with one another with regard to the most desirable set of characteristics such as weight, efficiency, bandwidth, average power capability, and modulation characteristics. The Crestatron amplifier described here affords a means of optimizing several of these characteristics in one device for certain applications.

In transmitter output tubes, where power supply requirements are severe and high efficiency is very desirable, a power tube with high efficiency, broad bandwidth, short length, and no attenuator would be very desirable in most systems applications. It is feasible to build high gain in the low-power stages where high efficiency is not of paramount importance and thus only moderate gain of the final output tube is required.

The Crestatron amplifier is a form of traveling-wave device which operates on a beating-wave principle in that three constant-amplitude r-f waves, arising from

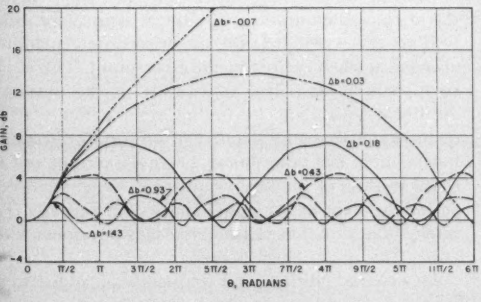

Fig. 1. Gain vs. length. ($C = 0.1$, $QC = 0.25$, $d = 0$, $b_{z1=0} = 2.57$).

the r-f voltage at the input and traveling at different phase velocities along an r-f circuit, beat with one another to produce a power gain. Two of the waves are out of phase at the input and the device length is chosen so that at its output the waves add in phase.

The Crestatron amplifier is a form of traveling-wave velocity sufficiently larger than the circuit phase velocity

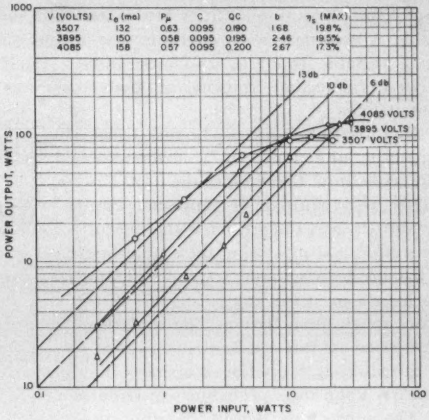

Fig. 2. Power output vs. power input for the 5-8-3 crestatron at 3.0 kmc.

so that the wave propagation constants are purely imaginary and only constant-amplitude waves traveling at different phase velocities exist on the structure. The stream voltage (velocity) is considerably higher than that used in the conventional growing-wave amplifier, which leads to an increased efficiency and power output over the growing-wave device. The gain of the Crestatron is proportional to the excess velocity over that at which the conventional growing-wave gain goes to zero. This is the point on the propagation constant diagram where the propagation constants change from complex values to purely imaginary ones. [1]

The theoretical gain of the Crestatron is shown in Fig. 1 for a typical set of circuit and stream parameters. Clearly this is a broadband phenomenon.

A number of *S*-band experimental tubes have been built and tested with good success. A typical power output vs. power input curve is shown in Fig. 2. At relatively high drive levels the saturation power output is near 130 watts with a gain of 6 db. Gains near 10 db at the 100-watt level are typical for this tube. The operating efficiency is near 20% for this low beam perveance and may be increased significantly by using higher-perveance electron guns. The Crestatron has no r-f attenuator to limit either the saturation power or efficiency, and the impedance matches of both the input and output coaxial cavities are good.

Digest of paper 60-1411, recommended by the AIEE Electronics Committee and approved by the AIEE Technical Operations Department for publication. Published in AIEE *Communication and Electronics*, Jan. 1961, pp. 828-33.

J. E. Rowe, G. T. Konrad, and H. W. Krage are with the University of Michigan, Ann Arbor, Mich.

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Analysis of Amplitude-Quantized Sampled-Data Systems

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QUANTIZATION, or round-off, takes place whenever physical quantities are represented numerically. A quantizer is an operator that assigns a value to a variable equal to its closest integer. Analog-to-digital conversion consists of both sampling and quantizing.

Quantization noise is bounded between $\pm 1/2$ a quantum unit, and can be made small by choice of the basic unit. The smaller the unit, however, the more digits are required to represent the same physical quantities, and the greater is the difficulty and expense in storing and processing these quantities. To establish a balance between accuracy and economy, it is necessary to have a means of evaluating the distortion resulting from rough quantization. The analysis of quantization developed in this article is a statistical one. Although a quantizer is a nonlinear operator to signals, it acts linearly upon their probability distributions.

The probability density distribution of a quantizer output signal is discrete, consisting of a series of uniformly separated impulses, with spacing equal to the quantization box q. This density has a characteristic function (Fourier transform) which is periodic with a "frequency" $\varphi = 2\pi/q$. A comparison of quantization with the addition of a statistically independent noise uniformly distributed (between plus and minus $q/2$) shows that the quantizer output distribution density consists of samples of the distribution density of signal plus noise. Satisfaction of a quantizing theorem (like the sampling theorem for signals) assures that the statistics of a process can be recovered from statistics of its quantized samples.

Quantization noise is causally related to the quantizer input signal, yet in many respects, it behaves as if it were independent. When the quantizing theorem is satisfied, quantizing noise turns out to be precisely first-order flat-topped distributed, and is uncorrelated with the signal. The quantization of high-order (correlated) signals compares with the addition of first-order noise (statistically independent, white). When a multidimensional quantizing theorem is satisfied, quantization noises are first-order, even though signals may be highly correlated.

Statistical systems analyses are especially simple when the quantizing theorem is satisfied. The first step in any analysis is therefore a check for the extent of the satisfaction of the quantizing theorem. This has been done for the particular case of Gaussian-distributed signals, and the results give a general indication of how rough quantization can be, and yet the quantizing theorem may be considered satisfied to a good approximation. With a quantization box size q as large as three standard deviations, there will be only a 10% error in the theoretical mean square of the quantization noise, and an input which is 80% correlated will yield a quantization noise which is only 30% correlated (rather than completely uncorrelated). This represents very rough quantization, where two quantum levels cover a range of six standard deviations. Moments and densities can therefore be recovered to a good approximation when process samples are quantized to be either positive or negative and this has been demonstrated experimentally. Satisfaction of the quantizing theorem is not a stringent condition in most practical situations.

When the quantizing theorem is satisfied, the quantizer may be replaced by a source of independent first-order uncorrelated noise having zero mean and a mean square of $q^2/12$. Several examples are given to illustrate how this fact is used in the recovery of moments, distribution densities, and correlation functions from roughly quantized data. Examples are given to show how a quantized feedback system may be analyzed.

A "linear" quantizer system has an output consisting of the sum of two components. The first component is the same as the output of the linear equivalent (identical system except that the quantizers are replaced by unit gains) when excited by the given input. The second component is described statistically as the output of the linear equivalent, having no input signal, with the quantizer replaced by a source of uniformly-distributed independent first-order noise. The noise output and the characteristics of the linear equivalent system will both be independent of the signal and will completely characterize the situation for the large class of inputs which satisfy the quantizing theorem.

An external "dither" can frequently be added to the input of a quantizer feedback system to improve performance. The dither acts like a catalyst in insuring satisfaction of the quantizing theorem, and is filtered out by the feedforward member before reaching the output point. Sinusoidal, random Gaussian, or other independent signals may be injected to achieve this effect irrespective of the characteristics of the actual input signal. The effects of "dead zone" can be eliminated, systems can be "statistically linearized," and low-frequency limit cycles can be elimininated. Injection of an external dither can convert a very crude control system, one containing rough quantization, saturating quantization, or even hysteresis (as in contactor systems) to a beautifully linear, almost noise-free control system.

Digest of paper 60-1240, "Statistical Analysis of Amplitude-Quantized Sampled-Data Systems," recommended by the AIEE Feedback Control Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Chicago, Ill., Oct. 9-14, 1960. Published in AIEE *Applications and Industry*, Jan. 1960, pp. 555-68.

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INSTITUTE ACTIVITIES

Summer General Meeting To Be Held June 18-23 at Cornell

David G. Allen

AN INSPECTION TRIP to the Cornell Ornithology Laboratory will be held Tuesday, June 20, at 1:30 p.m., during the Summer General Meeting. Woodland trails and a comfortable glassed-in area within the laboratory are available for observation and study of many species of birds, ducks, geese, and herons.

THE 1961 AIEE Summer General Meeting will be held on the Cornell University campus at Ithaca, N.Y., starting with the informal tea on Sunday afternoon, June 18, and extending through Friday, June 23.

The Annual Meeting of the Institute will be held at 2 p.m. on Monday, June 19. The meeting will be called to order by the general chairman of the meeting, W. H. Erickson. AIEE Treasurer W. R. Clark will present his report to the members and this will be followed by AIEE President C. H. Linder, who will give his report and that of the Board of Directors.

AIEE members will then hear the report of the Committee of Tellers on the vote for the Constitutional Amendments and the nominees for AIEE officers for the coming year. This will be followed by the presentation of the President's Badge to the incoming president, W. H. Chase.

J. G. Trump will be presented with the Lamme Medal. J. H. Chiles will give the history of the medal and H. R. Stewart will give the biography of the Medalist. An AIEE Honorary Membership Certificate will be presented to A. B. DuMont, chairman of the board, Allen B. DuMont Laboratories.

The tentative technical program follows:

Monday, June 19

10:00 a.m. Indicating and Integrating Instruments, and Telemetering

61-719. The Design of a Repulsion Magnetic Bearing for Watthour Meters. *D. F. Wright*, Westinghouse Elec. Corp. (Re-presented for discussion only)

61-720. Photoelectric Impulse Generation Devices for Demand Metering. *R. E. Whipple*, General Elec. Co.

CP.* A New Kind of Tachometer. *W. H. Middendorf*, Univ. of Cincinnati; *F. C. Weimer*, Ohio State Univ.

61-721. A General Description of D-C Digital Voltmeters. *C. Stansbury*, U. S. Dept. of Commerce (Re-presented for discussion only)

CP.* A Differential Thermocouple Voltmeter. *J. E. Griffin, F. L. Hermach*, National Bureau of Standards

S-111-A. A Bibliography on Telemetering—An Addendum. *C. A. Mabey*, Bristol Co. (Price $1.50 to all)

10:00 a.m. Computer Technology

CP.* Considerations in the Development of an Optical Character Recognition System. *J. J. Leimer*, IBM Development Lab.

61-725. A Comparison of Computers. *F. G. Curl*, Calif. Inst. of Technology

61-724. Results of Simulation Comparison of Control Computers. *G. T. Sendzuk*, General Elec. Co.

CP61-726. Automation of Logic Page Printing. *C. R. Warburton*, IBM

CP.* A Technique for Implementing Synchronous Sequential Relay Circuitry. *R. L. Gaublin, M. P. Marcus, C. J. Tunis*, IBM Development Lab.

61-732. Large-Scale On-Line Data Processing Systems. *S. Levine*, Teleregister Corp. (Re-presented for discussion only)

60-1007. A Computer Program for Preparing Wiring Diagrams. *Mrs. D. B. Kirby, C. W. Rosenthal*, Bell Telephone Labs. (Re-presented for discussion only)

61-814. Forcing Circuitry—Sequential Building Blocks for Logical Design. *R. M. Meade*, IBM (Re-presented for discussion only)

60-1283. Boolean Prime Implicants by the Binary Sieve Method. *F. B. Hall*, Argonne National Lab. (Re-presented for discussion only)

*Conference papers will not be reprinted by the Institute; however, they may be available at the meeting at the discretion of the author.

THIS copper wheel engraving will be viewed during a tour of the Corning Glass Center, Corning, N. Y., which will be held at the Summer General Meeting. Many of the Steuben Glass pieces are engraved with intricate art work.

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10:00 a.m. Microsystem Electronics

CP.* An Approach to Circuit Integration. *H. Kihn* RCA Labs.

CP.* Molecular Electronics. *H. C. Lin, J. P. Stelmak, G. Strull,* Westinghouse Corp.; *W. Lukac,* American Bosch Arma Corp.

CP.* The Hall Effect Mapper. *J. A. Dickerson,* IBM

2:00 p.m. Annual Meeting

Tuesday, June 20

9:00 a.m. Section Delegates Conference

9:00 a.m. Hydro Power Generation

61-772. The Cowans Ford Project. *J. Q. Wray,* Duke Power Co.

CP61-818. An Electric-Hydraulic Governor for Hydraulic Turbines. *N. G. Dennis,* Woodward Governor Co.

CP.* Electrical Features of the Niagara Power Project. *T. E. Thorgerson,* Charles T. Main, Inc.

CP.* Electrical Controls and Protective Relaying-Niagara Power Project. *T. E. Thorgerson, J. Basilesco,* Charles T. Main, Inc.

9:00 a.m. D-C Machinery

61-766. D-C Motor Flashover Torque. *H. J. McLean, O. C. Coho,* General Elec. Co.

61-760. Design of Self-Compensated High-Current Comparatively Higher Voltage Homopolar Generators. *A. K. Das Gupta,* Ill. Inst. of Technology

CP61-820. A New D-C Motor Concept with Motor Designs. *G. A. Oberbeck,* Mass. Inst. of Technology

61-763. Ribbon Generators With MHD Generator and Other Implications. *A. D. Moore,* Univ. of Mich.

9:00 a.m. System Planning and Economics

61-780. Hydro-Thermal Economic Scheduling —Part II: Extension of the Basic Theory. *B. Bernholtz, L. J. Graham,* Hydro-Electric Power Commission of Ontario (Re-presented for discussion only)

61-824. Hydro-Thermal Economic Scheduling —Part III: Scheduling the Thermal Subsystem Using Constrained Steepest Descent. *B. Bernholtz, L. J. Graham,* Hydro-Electric Power Commission of Ontario (Re-presented for discussion only)

CP61-798. Improving Transient Stability by Use of Dynamic Braking. *W. H. Croft, R. H. Hartley,* Arizona Public Service Co.

61-727. Limiting Curves for Transient Stability—A Digital Program for Evaluating Operating Guides for Synchronous Generators Connected to Large Systems. *A. Johannesen, J. A. Harle,* Univ. of Alberta

CP61-797. Calculation of Short Circuits Using A High-Speed Digital Computer. *A. H. El-Abiad,* Purdue Univ. and American Elec. Power Service Corp.; *R. Guidone, G. W. Stagg,* American Elec. Power Service Corp.

9:00 a.m. Semiconductor Rectifying Devices and Power Supplies

CP.* Characteristics and Applications for the 100-Ampere Trimistor. *W. F. Munzer,* Westinghouse Elec. Corp.

CP61-716. Simplified Method for Measuring Nanosecond Reverse Recovery Time on Diodes. *B. Szabo,* IBM Data Systems Div.

CP.* Transient Voltage Suppression in Silicon, Germanium, and Controlled Rectifier Circuitry. *C. E. Arnold,* General Elec. Co.

61-717. 30-Volt 10-Ampere Regulated Power Supply Using the Variable Output Transistor Oscillator with Current Transformer. *S. P. Jackson,* Continental Electronics Corp.

CP.* Silicon Controlled Rectifier High-Voltage Power Supply. *G. E. Snyder,* General Elec. Co.

61-718. A Silicon Controlled Rectifier Inverter With Improved Commutation. *W. McMurray, D. P. Shattuck,* General Elec. Co. (Re-presented for discussion only)

9:00 a.m. Communication Switching I

61-722. A New Design for Customer Group Telephone Service in the Modern Business Community. *P. D. Shea,* New York Telephone Co.

CP61-815. A New Technique for Establishing a Connection Through Crosspoint Networks, Permitting Simplification of Solid-State Space-Division Switching Systems. *M. S. Macrander,* Automatic Elec. Labs.

CP61-729. An Electrically Controlled PAX—Its Design and Performance. *S. Yamato, K. Watanabe, K. Muroga, J. Okuda,* Nippon Elec. Co.

CP61-817. The Relative Merits of Time Division Multiplex Versus Space Division as a Mode of Operation for Electronic Telephone Exchanges. *J. G. Pearce,* General Dynamics Electronics

61-825. Transmission Network of an Electronic Crosspoint PABX. *R. F. Kowalik,* Automatic Electric Labs. (Re-presented for discussion only)

61-826. Logical Control of an Electronic Crosspoint PABX. *R. P. Sanders,* Automatic Electric Labs. (Re-presented for discussion only)

61-827. Features of an Electronic Crosspoint PABX. *J. G. Van Bosse, J. DeCicco,* Automatic Electric Labs. (Re-presented for discussion only)

2:00 p.m. Section Delegates Conference

2:00 p.m. Induction Machinery

61-761. Saturation Harmonics of Polyphase Induction Machines. *C. H. Lee,* Westinghouse Elec. Corp.

CP61-762. Derivation of the Basic Constants of the General Induction Machine in Terms of Winding Parameters. *T. D. Graybeal,* Siegel Co.

CP.* Advanced Design of Printed Motor Employing Barium Ferrite Field Structure. *F. A. Higgins,* Photocircuits Corp.

CP61-764. A Magnetic Amplifier Voltage Regulator for a Brushless A-C Generator Using the New "FCE" Frequency Converter Excitation System. *A. F. Szippl, K. M. Sparrow,* Lima Elec. Co.

CP61-765. The Induction Frequency Converter Saturable Reactor (FCE-SR) As An Exciter-Regulator for a Brushless A-C Generator. *K. M. Sparrow,* Lima Elec. Motor Co.

2:00 p.m. System Engineering, and Transmission and Distribution

61-805. Voltage Nomenclature—Secondary and Utilization Systems. *A. S. Anderson,* Ebasco Services

CP61-790. Improvements of Electric Service Performance—Part I: Service and Facility Performance Records. *J. J. Malone, R. K. Moore,* Penn. Power & Light Co.; *N. N. Smeloff,* Allentown, Pa.

CP61-750. Improvement of Electric Service Performance—Part II: Selective Modernization of Distribution. *J. E. Weed, R. K. Moore,* Penn. Power & Light Co.; *N. N. Smeloff,* Allentown, Pa.

CP61-751. Improvement of Electric Service Performance—Part III: Greater Protection and Automation of Distribution. *J. E. Treweek, R. K. Moore,* Penn. Power & Light Co.; *N. N. Smeloff,* Allentown, Pa.

2:00 p.m. Research and Management

CP61-800. Costs of Supporting Functions of Research and Development Laboratories. *H. T. Thompson,* General Elec. Co.

61-801. Controller's Function as it Applies to Research and Development in Industry. *C. S. Van Wormer,* General Elec. Co.

Wednesday, June 21

9:00 a.m. Industrial and Commercial Power Systems, Relays

CP.* Testing Protective Devices on Industrial Plant Power Systems. *R. J. Dikeman, Jr., R. M. Shoop,* Multi-Amp Electronic Corp.

CP.* A Survey of Current Industrial Relay Protection. *J. J. O'Connor, N. Peach,* Power Magazine

CP61-799. Team Work—The Key to Electrical Service Continuity for Continuous Process Plants. *M. M. Gilbert,* E. I. du Pont de Nemours & Co.

CP61-829. What the Industrialist Should Know and Do When Arranging to Obtain Utility Power. *W. E. Marter,* Duquesne Light Co.; *A. Hausburg,* American Elec. Power Service Corp.

9:00 a.m. Operating Experience Nuclear Power Plants

CP.* Selected Operating Experience of Commission Power Reactors. *J. O. Roberts,* U. S. Atomic Energy Commission

CP.* Operating Experience at the Dresden Nuclear Power Station. *J. A. Haaga,* General Elec. Co.; *K. F. Hempstead,* Commonwealth Edison Co.

CP.* Control and Transient Performance of the Dresden Nuclear Power Station. *E. R. Owen, W. I. Collett,* General Elec. Co.

9:00 a.m. Transmission and Distribution

CP.* Bibliography of Bundled Conductors. AIEE Working Group of Towers, Poles & Conductors Subcommittee. H. B. White, chairman

CP61-823. Thermal Limits of Overhead Conductors at Various Meteorological Conditions. *J. A. McElyea,* Ill. Power Co.

CP61-813. The Electrical Properties of Single-Layer Aluminum Conductors, Steel Reinforced (ACSR) Having Single Steel Core Wires with Heavy Aluminum Coating. *C. H. Jensen,* Copperweld Steel Co.; *R. E. DeMuth, R. W. Mowery,* Battelle Memorial Inst.

CP61-791. Transmission Characteristics of the Near Signal. *L. Runge,* Midwest Research Inst.

9:00 a.m. Electrical Insulation

61-757. Simplified Methods of Calculating Insulation Life Characteristics. *L. C. Whitman,* General Elec. Co.

61-758. Thermal Endurance of Enamelled Wires Using Twisted Wire Specimens Statistical Analysis of Test Results. *H. Goldenberg,* Electrical Research Association Lab.

9:00 a.m. Management

CP.* Responsibilities of an Engineering Manager as Seen by the Engineer. *W. J. Dowis, D. W. McLenegan,* General Elec. Co.

CP.* The Young Engineer Looks at Management. *N. J. Bowmaker,* Baltimore Gas and Elec. Co.

CP.* The Use of Psychological Service in Manager Selection and Development. *L. D. Edmonson,* William, Lynd and Williams

9:00 a.m. Wire Communications and Data Communications

61-774. The 81-A Exchange Trunk Carrier System. *M. E. Ferguson, M. C. Harp,* Lenkurt Elec. Co.

CP61-775. The 81-A Exchange Trunk Carrier System-Repeaters and Regulation. *E. A. Gilmore, C. G. Griffith,* Lenkurt Elec. Co.

CP61-776. The 81-A Exchange Trunk Carrier System-Signaling. *E. F. Tuck, D. K. Melvin,* Lenkurt Elec. Co.

CP61-777. The 81-A Exchange Trunk Carrier System-Applications. *L. R. Cool, R. G. Walker,* Lenkurt Elec. Co.

CP.* Economical Short-Haul Four-Wire Circuits. *J. A. Lee, E. L. Fletcher,* New York Telephone Co.

61-822. Reliable Data Transmission Through Noisy Media—A Systems Approach. *C. M. Melas,* IBM (Re-presented for for discussion only)

9:00 a.m. Insulated Conductors

CP.* A 69-Kv High-Pressure Gas-Filled Aluminum Sheath Aerial Cable. *F. W. Mahley,* Long Island Lighting Co.; *E. J. Merrell,* Phelps Dodge Copper Prod. Corp.

61-736. Cable Sheath Insulation Requirements to Withstand Abnormal Voltage Stresses. *F. O. Wollaston, K. H. Kidd,* International Power & Engineering Consultants

61-737. The Role of Grounding Cells and Similar Devices in the Effective Cathodic Protection of Lead Sheathed Power Cables of Substation Exit Systems. *S. E. Trouard, M. J. Maier,* New Orleans Public Service

2:00 p.m. Industrial and Commercial Power Systems

CP.* Expansion of the Electrical Distribution System in a Chemical Plant. *A. H. Barth,* Monsanto Chemical Co.

CP61-768. Selective Relaying for the Synchronizing Bus Industrial Distribution Systems. *D. C. Burke,* General Elec. Co.

CP.* Rectifier Applications in a Steel Plant. *K. Forster,* Algoma Steel Corp.

CP61-767. Line to Enclosure Impedances—Use of Ground Fault Trip Devices to Limit Arcing Damage. *L. E. Fisher,* General Elec. Co.

CP.* Design of a Single Screw Industrial Terminal Connector. *T. C. Price,* Burndy Corp.

2:00 p.m. Design Features of Nuclear Power Plants

CP61-771. Electrical Features of the Elk River Reactor Plant. *D. C. McClintock,* Sargent & Lundy

CP.* A Nuclear Unit at the Humboldt Bay Power Plant. *J. O. Schuyler, J. W. Colwell,* Pacific Gas & Elec. Co.

CP.* Power Distribution at Boiling Nuclear Superheat Power Station, Puerto Rico. *E. L. Bottum,* Jackson and Moreland; *F. Bevilaqua,* General Nuclear Engineering Corp.

CP.* Simultaneous Operation of a Nuclear and Coal Fired Power Plant—HNPF. *C. L. Dunsmore,* Atomics International

2:00 p.m. Power Generation, and Transmission and Distribution

Technical Matters To Be Aired at Forum

A Forum of technical committee chairmen and others concerned with Technical Operations Department matters will be held in connection with the Summer General Meeting, at Ithaca, N. Y., in Room 101, Phillips Hall, Cornell University, at 7:30 p.m., Thursday, June 22, 1961.

Scheduled are brief addresses by AIEE Pres. C. H. Linder; Dr. B. G. Ballard, chairman of the Research Committee; Dr. R. A. Ramey, chairman of the New Technical Activities Committee, and A. P. Hayward, chairman of the Ad Hoc Committee on Processing, Quality, and Distribution of Papers.

61-784. Digital Traveling-Wave Solutions—Part I: Single-Phase Equivalents. *L. O. Barthold, G. K. Carter,* General Elec. Co.

CP61-785. Experience with Line Dropping Up to 500-Kv at Hydro-Quebec. *L. Cahill,* Quebec Hydro Electric Commission; *P. A. Baltensperger,* Brown Boveri & Co.

61-786. Investigations Concerning the Possibility of Dangerous Resonance Conditions at the Breed Plant During Unit Maintenance and Unit Startup. *S. G. Vassiliev, V. P. Rader,* American Elec. Power Service Corp.

61-787. The Breed Plant Transmission System: Conceptual, Feasibility, and Design Studies. *C. F. De Sieno, A. Hausburg,* American Elec. Power Service Corp.

2:00 p.m. Education in Electrical Insulation

CP.* Opportunities for Electrical Engineers in the Field of Electrical Insulation. *K. Mathon,* General Elec. Co.

CP.* How the Modern College Prepares the Student for Work in Dielectrics and Insulation.

CP.* The Need for Research in Insulating Materials. *J. Swiss,* Westinghouse Elec. Corp.

CP.* Industry's Outlook on Education in Dielectrics. *J. R. Perkins, Jr.,* E. I. du Pont de Nemours & Co.

CP.* How To Train the Young Engineer To Apply Basic Principles to the Solution of Insulation Problems. *M. L. Manning,* South Dak. State Coll.

2:00 p.m. Wire Communications

CP61-778. Speech Volume on Bell System Message Circuits. *K. L. McAdoo,* Bell Telephone Labs.

61-653. Loop Around Transmission Test Circuit for Step by Step CDO's Having Verification Train. *F. O. Richardson, J. J. Clark,* New England Tel. & Tel. Co.

CP61-816. Comparative Transmission Characteristics of Polyethylene Insulated and Paper Insulated Communication Cables. *T. C. Henneberger, M. D. Fagen,* Bell Telephone Labs.

61-779. Electrical Uniformity and Deviations Control in Polyethylene Insulated Multipaired Telephone Cables. *W. L. Roberts,* Superior Cable Corp.

2:00 p.m. Insulated Conductors

61-738. Some Considerations Concerning Extra-High Voltage A-C Cable Power Transmission. *J. M. Oudin,* Cables de Lyon; *R. A. Tellier,* Electricite de France

61-739. Effect of Temperature Gradient on Moisture Migration in Granular Media. *C. M. Wong,* United Technology Corp.; *F. K. Hoh,* IBM; *W. A. Hadley,* Linotype & Machinery; *H. D. Baker,* Columbia Univ.

61-242. Nondestructive Inspection of Cable Terminations and Splices by X-Ray Analysis. *T. L. Bourbonnais* II, E. I. du Pont de Nemours & Co.

61-730. Objectives for Overcoming Temperature and Electrical Stress Barriers of EHV Cable Insulation Through Molecular Design. *J. J. Grebe, R. C. Mildner,* Dow Chemical Co. (Represented for discussion only)

2:00 p.m. Linear Control Systems

61-753. Realization of Transfer Functions. *M. Smith,* MIT

CP61-741. A Stability Investigation of Time-Varying Linear Systems. *G. P. Szego,* Purdue Univ.

61-728. On Linear Control Theory. *P. D. Joseph, J. T. Tou,* Purdue Univ.

61-752. Feedback Compensation: A Design Technique. *G. J. Thaler, J. D. Bronzino, D. E. Kirk,* U. S. Naval Postgraduate School

Thursday, June 22

9:00 a.m. Control Systems Analysis

61-828. Phase Space Analysis and Design of Linear Discontinuously Damped Feedback Control Systems. *K. W. Han, G. J. Thaler,* U. S. Naval Postgraduate School (Re-presented for discussion only)

61-754. An Introduction to Lyapunov's Second Method. *W. J. Cunningham,* Yale Univ. (Re-presented for discussion only)

CP61-830. Use of an Incremental Computer in a Feedback Control System. *C. E. Baker,* McDonnell Aircraft Corp.

CP61-748. Limit Cycles of a Sampled-Data Relay Servo Using the Z-Transform and Describing Function. *J. S. Demetry,* U. S. Naval Postgraduate School

61-819. Mathematical Models for Time-Domain Design of Electro-Hydraulic Servomechanisms. *P. K. C. Wang,* IBM

9:00 a.m. Power System Communications

61-806. Digital Computer Solution of a Microwave Reflector Problem. *C. McCord, J. W. Vinyard,* TVA

61-807. A Repeater Receiver for the Near System. *D. R. Cleary,* Midwest Research Inst.

61-808. Receivers for the National Emergency Alarm Repeater System. *J. H. Inderwiesen,* Midwest Research Inst.

9:00 a.m. Transmission and Distribution

CP61-792. Field Tests on an Interrupter Switch for Capacitor Service. *J. J. Mikos,* S&C Elec. Co.; *V. P. Rader,* American Elec. Power Service Corp.

61-740. Field Patterns of Bundle Conductors and Their Electrostatic Properties. *A. S. Timascheff,* Aluminum Co. of Can.

61-793. Extra-Long-Distance Transmission. *E. W. DuBois, J. F. Fairman, Jr., C. M. Murphy,* Westinghouse Elec. Corp.; *D. E. Martin, J. B. Ward,* Pacific Power & Light Co.

9:00 a.m. Electromechanical Energy Conversion—System Analysis

CP61-734. Support of Endowed Colleges By Industry. *M. G. Malti,* Cornell Univ.

Note: The following three papers are being preprinted under one cover and will have the same number. (Price $1.25 to all)

S-128. A Decade of Experience in Teaching Kron's Approach to Generalized Sys-

tems Theory. *T. J. Higgins*, Univ. of Wis.

S-128. An Abstract Mathematical Basis for Network Analogies and Its Significance in Physics and Engineering. *F. H. Branin, Jr.*, IBM Products Development Lab.

S-128. Kirchoff's Versus Lagrange's Postulates as a Basis of System Analysis. *H. E. Koenig*, Mich. State Univ.

61-733. Educating Electrical Engineers for Professional Careers. *S. Linke*, Cornell Univ. (Re-presented for discussion only)

61-735. Some Thoughts on Motivation Through Challenge. *W. C. Johnson, P. R. Clement*, Princeton Univ. (Represented for discussion only)

9:00 a.m. Radio Astronomy

CP.* Observations of Extraterrestrial Radio Noise. *P. F. Weaver*, Cornell Univ.

CP.* Auroral Radar Phenomena. *W. Flood*, Cornell Aero Lab.

CP.* Radio Investigations of the Moon. *T. Gold*, Cornell Univ.

CP.* A New Method of Space Exploration by Radar. *T. Laaspere*, Cornell Univ.

2:00 p.m. Sample Data Control Systems

CP.* An Input Self-Adaptive Pulse-Data System. *C. K. Taft*, Cleveland, Ohio

61-743. Sampled-Data Control Systems with Transport Lag by Mitrovic's Algebraic Method. *D. Siljak*, Beograd, Jugoslavia

61-749. Optimum Synthesis of Multiport Systems Containing Modulators with Periodic Carriers. *J. F. Egan, G. J. Murphy*, Northwestern Univ.

CP61-742. An Analog Simulation of a Discrete Compensator for a Sampled Data System. *R. C. Dorf*, U. S. N. Postgraduate School; *R. L. Enos*, U. S. N. Guided Missiles School

2:00 p.m. Radio Noise

CP61-795. The Spectrum of Corona Noise Near A Power Transmission Line. *C. W. Helstrom*, Westinghouse Elec. Corp.

61-729. Radio Interference from High-Voltage Lines: Part I—Statistical Approach. *R. J. Mather, B. M. Bailey*, Bonneville Power Admin.

CP.* The Problem of Radio Noise Instrumentation. *W. E. Pakala*, Westinghouse Elec. Corp.

61-794. Digital Calculation of Radio Noise Levels. *A. K. Abboushi, L. O. Barthold*, General Elec. Co.

2:00 p.m. Electromechanical Energy Conversion—Undergraduate Courses

Note: The following four papers are being preprinted under one cover and will have the same number. (Price $1.25 to all)

S-128. Evaluation of a Program in Energy Conversion and Control. *K. A. Fegley*, Univ. of Pa.

S-128. Electromechanical Energy Conversion in the Undergraduate Curriculum at the University of Delaware. *E. Erdelyi*, Univ. of Del.

S-128. Electric Machinery in an Undergraduate Electrical Engineering Curriculum. *H. Majmudar*, Syracuse Univ.

S-128. Electric Machinery and System Engineering Courses. *P. L. Alger*, Rensselaer Polytechnic Inst., *O. I. Franksen*, Univ. of Denmark

CP.* Progress Report by the ASEE Committee to Survey the Teaching of Electromechanical Energy Conversion Courses. *A. D. Bailey*, Univ. of Ill.

7:30 p.m. Forum of Technical Committee Chairman

Friday, June 23

9:00 a.m. Control System Techniques

61-745. Experimental Determination of the Frequency Response of a Linear Transfer Function for Arbitrary Transient Inputs of Finite Duration. *W. W. Wierwille*, Cornell Univ.

CP61-746. A Digital Technique for Obtaining Sinusoidal Frequency Responses of any Block Diagram Configuration. *R. G. Abraham*, Westinghouse Elec. Corp.

CP61-811. Extremum Adaptation in Transient Drift of Multivariable Situations. *R. I. Van Nice*, Westinghouse Elec. Corp. (Formerly with Carnegie Inst. of Technology); *R. A. Mathias*, Carnegie Inst. of Technology

9:00 a.m. Substations and Power Generation

CP.* Middle of the Road Monitor or Solid-State Bearing Protection. *D. B. Seymour*, Westinghouse Elec. Corp.; *F. Carney*, N. Y. State Elec. & Gas Co.

61-781. Earth Resistivity Measurements for Grounding Grids. *A. L. Kinyon*, Vancouver, Wash.

61-782. G.P.U. — Penelec's 460-Kv Substations. *A. M. Baker*, Penn. Elec. Co.; *G. E. Hertig*, I-T-E Circuit Breaker Co.

CP61-810. Work Simplification Methods Applied to the Construction of Standardized Substations. *R. S. Melville*, Southern Calif. Edison Co.

61-785. Current Asymmetry in Resistance-Reactance Circuits — II. *E. T. B. Gross, B. Thapar*, Ill. Inst. of Technology

9:00 a.m. Transformers

CP61-788. Reactance of Toroidal Transformatoric Devices. *A. A. Halacsy*, Federal Pacific Elec. Co.

61-789. Optimization of Transformer Geometry by "Method of Finite Increments." *S. P. Jackson*, Continental Electronics Corp.

61-773. Distribution Transformer Magnetizing Inrush Current. *J. E. Holcomb*, General Elec. Co.

CP61-809. The feasibility of Superconducting Power Transformers. *R. McFee*, Arthur D. Little, Inc.

2:00 p.m. Substations

2:00 p.m. Electric Circuit Theory

61-802. On the Optimum Synthesis of Random Sampling Multipole Filters with Stationary Inputs. *H. C. Hsieh*, Univ. of Calif.

61-803. Maximization and Minimization of Complicated Multivariable Functions. *N. S. Bromberg*, Mass. Inst. of Technology

61-804. A Note on the Approximate Representation of a Curve with Linear Segments. *S. G. S. Shiva*, Bangalore, India

CP.* Solution of Initial-Valve Circuit Problems by Multiple Mellin Transforms. *T. J. Higgins*, Univ. of Wis.; *E. S. Ibrahim*, Purdue Univ.

75-Word Summaries To Be Required for Papers To Improve Service to Members

WITH the view toward providing a complete publications service, *Electrical Engineering* will carry from month to month 75-word summaries of all papers accepted. This service will become effective August 1, 1961, after which publication of the one-page, 1,000-word digests will be discontinued.

All authors should prepare 75-word summaries of their papers to be incorporated on the first page following the title and byline and after the word, "Summary." The summary should briefly state the purpose of the paper, stressing features which are new or novel, the method employed, and salient conclusions. The objective is to inform the reader of what the paper is about so that he may know whether or not to obtain a copy. The summary should not describe the paper but state affirmatively the subject matter. Example:

59-35. Equivalent Circuits for Overcurrent Calculations of Current Transformers. *E. E. Conner, T. R. Specht.* An equivalent circuit is given for current transformers applicable over both the normal and overcurrent ranges of operation. In the normal range of operation where the core is not saturated, the proposed equivalent circuit reduces to the same circuit that has been derived by others and has been in successful use for years. In the overcurrent range, tests made on sample transformers showed good correlation with calculated results.

The new ruling will become effective with papers prepared for presentation at the AIEE Fall General Meeting, Detroit, Mich., this year for which the closing date for Transactions Papers is June 14, 1961, and the closing date for preprinted Conference Papers is August 11.

New edition of the Author's Guide and the TOD (Technical Operations Department) Processing of Papers section of the TOD Manual will be modified accordingly.

Longer abstracts of each Conference Paper to be presented without preprinting are due in the hands of the technical committee chairmen or at headquarters on July 27. This is in addition to the 75-word summary previously described.

Conference on Magnetism and Magnetic Materials Scheduled

The 7th Annual Conference on Magnetism and Magnetic Materials will be held in Phoenix, Ariz., November 13-16, at the Hotel Westward Ho. This conference is sponsored jointly by AIEE and the American Institute of Physics, in co-operation with the Office of Naval Research, the Institute of Radio Engineers, and the Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers.

The deadline for abstracts is August 18. Further details can be obtained from the local chairman, P. B. Myers, Motorola Semiconductor Products Division, 5005 E. McDowell Road, Phoenix, Ariz.

AIEE Future Meetings

Railroad Computer and Automation Conference*
Engineering Societies Building and Pick-Carter Hotel
Cleveland, Ohio
June 6-7, 1961

Summer General Meeting*
Cornell University
Ithaca, N. Y.
June 18-23, 1961

Pulp and Paper Conference*
University of Western Michigan
Kalamazoo, Mich.
June 21-23, 1961

Aero-Space Transportation Conference*
Benjamin Franklin Hotel
Philadelphia, Pa.
June 26-30, 1961

AIEE-AIChE-ASME-IRE-ISA Joint Automatic Control Conference*
University of Colorado
Boulder, Colo.
June 28-30, 1961

JECM&B-IFME International Conference on Medical Electronics*
Waldorf-Astoria Hotel
New York, N. Y.
July 16-21, 1961

Pacific General Meeting
Hotel Utah
Salt Lake City, Utah
August 23-25, 1961
(Final date for †TP—closed, ‡CP Syn.—June 5, CPMs—June 19)

AIEE-IRE-ISA Joint Nuclear Instrumentation Conference
North Carolina State College
Raleigh, N. C.
September 6-8, 1961
(Final date for †TP—June 8, ‡CP Syn.—June 23, CPMs—July 3)

AIEE-ASME Engineering Management Conference
Hotel Roosevelt
New York, N. Y.
September 14-15, 1961
(Final date for †TP—June 16, ‡CP Syn.—June 30, CPMs—July 11)

Petroleum Industry Conference
Jung Hotel
New Orleans, La.
September 17-20, 1961
(Final date for †TP—June 19, ‡CP Syn.—July 5, CPMs—July 14)

AIEE-ISA-IRE Industrial Electronics Conference
Bradford Hotel
Boston, Mass.
September 20-21, 1961
(Final date for †TP—June 22, ‡CP Syn.—July 7, CPMs—July 17)

AIEE-ASME National Power Conference
St. Francis Hotel
San Francisco, Calif.
September 24-27, 1961
(Final date for †TP—June 26, ‡CP Syn.—July 11, CPMs—July 21)

NOTICE TO AUTHORS

Strict compliance with the "Author's Guide" will save you time, delays, and unnecessary correspondence. For a copy, write to E. C. Day, 33 West 39 St., New York 18, N.Y.

AIEE-IRE-EIA-SMPTE National Electronics Conference
Sherman Hotel
Chicago, Ill.
October 9-11, 1961
(Final date for †TP—July 11, ‡CP Syn.—July 26, CPMs—Aug. 4)

Fall General Meeting
Statler-Hilton Hotel
Detroit, Mich.
October 15-20, 1961
(Final date for †TP—June 14, ‡CP Syn.—July 27, CPMs—Aug. 11)

Machine Tools Conference
Faust Hotel
Rockford, Ill.
October 16-18, 1961
(Final date for †TP—July 18, ‡CP Syn.—Aug. 2, CPMs—Aug. 11)

Middle Atlantic (Fall) Textile Conference
Barringer Hotel
Charlotte, N. C.
October 19-20, 1961
(Final date for †TP—July 21, ‡CP Syn.—Aug. 4, CPMs—Aug. 15)

AIEE-IRE-U of Nebr. Biomedical Instrumentation and Engineering Conference
Sheraton-Fontenelle Hotel
Omaha, Nebr.
October 26-27, 1961
(Final date for †TP—July 28, ‡CP Syn.—Aug. 11, CPMs—Aug. 22)

Western Appliance Conference
Biltmore Hotel
Los Angeles, Calif.
November 6, 1961
(Final date for †TP—Aug. 8, ‡CP Syn.—Aug. 23, CPMs—Sept. 1)

Nonlinear Magnetics Conference
Statler-Hilton Hotel
Los Angeles, Calif.
November 6-8, 1961
(Final date for †TP—Aug. 8, ‡CP Syn.—Aug. 23, CPMs—Sept. 1)

AIEE-AIP Magnetism and Magnetic Materials Conference
Westward Ho Hotel
Phoenix, Ariz.
November 13-16, 1961
(Final date for †TP—Aug. 14, ‡CP Syn.—Aug. 29, CPMS—Sept. 8)

AIEE-IRE-ACM Eastern Joint Computer Conference
Sheraton-Park Hotel
Washington, D. C.
December 10-14, 1961
(Final date for †TP—Sept. 11, ‡CP Syn.—Sept. 26, CPMs—Oct. 6)

AIEE-IRE-ASQC National Symposium on Reliability Control
Statler Hilton Hotel
Washington, D. C.
January 9-11, 1962
(Final date for †TP—Oct. 11, ‡CP Syn.—Oct. 26, CPMs—Nov. 6)

Winter General Meeting
Hotel Statler
New York, N. Y.
January 28-February 2, 1962
(Final date for †TP—Oct. 30, ‡CP Syn.—Nov. 9, CPMs—Nov. 24)

South Central District Meeting
Hotel Peabody
Memphis, Tenn.
April 4-6, 1962
(Final date for †TP—Jan. 4, DPMs—Jan. 29)

Great Lakes District Meeting
Hotel Van Orman
Fort Wayne, Ind.
April 18-20, 1962
(Final date for †TP—Jan. 18, DPMs—Feb. 9)

South West District Meeting
Hotel Chase
St. Louis, Mo.
April 30-May 2, 1962
(Final date for †TP—Jan. 30, DPMs—Feb. 23)

Middle Eastern District Meeting
Hotel DuPont
Wilmington, Del.
May 7-9, 1962
(Final date for †TP—Feb. 6, DPMs—Mar. 2)

North Eastern District Meeting
Hotel Statler
Boston, Mass.
May 9-11, 1962
(Final date for †TP—Feb. 8, DPMs—Mar. 5)

Empire District Meeting
Erie, Pa.
May 14-16, 1962
(Final date for †TP—Feb. 13, DPMs—Mar. 9)

Summer General Meeting
Hotel Denver Hilton
Denver, Colo.
June 17-22, 1962
(Final date for †TP—Mar. 19, CPMs—April 11)

AIEE-AIChE-IRE-ISA-ASME Joint Automatic Control Conference
New York University
New York, N. Y.
June 27-29, 1962
(Final date for †TP—Mar. 29, ‡CP Syn.—April 13, CPMs—April 23)

*Final date for submitting papers—closed

†**TP**—Transactions Paper
‡**CP Syn.**—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

THIS copper mine in Utah's Bingham Canyon is the largest open pit copper mine in the world and the largest man-made excavation. The mine produces more than a half billion pounds of copper every year. It is more than a half mile deep, almost 2 miles wide. About 200 miles of electrified railroad travels the mine's benches in order to take ore 16 miles to processing plants. An inspection trip to this mine will be held during the Pacific General Meeting.

Pacific General Meeting To Be Held August 22-25, 1961, in Salt Lake City, Utah

THE 1961 Pacific General Meeting of AIEE will take place August 22-25 in Salt Lake City, Utah. Registration will commence Tuesday evening, August 22, in the Hotel Utah which will be headquarters for the meeting. Highlighting the meeting will be technical sessions scheduled for Wednesday through Friday.

Hotel reservations are being handled by the facilities committee, with F. O. Wald as chairman. Mr. Wald may be contacted for information and reservations at the Utah Power and Light Company, Box 899, Salt Lake City, Utah.

The technical program will consist of technical papers selected to match the diversity of industry in the host state of Utah. Centered near Salt Lake City are a wide variety of space-age manufacturing facilities involved in products ranging from electronics to solid fuel propellants, in addition to the long established copper and steel mining and milling plants. The technical program is being arranged through the Technical Operations Department of the Institute.

Inspection Trips Arranged

An inspection trip has been scheduled for Wednesday to the copper mining, milling, smelting, and refining operation of Kennecott Copper Corporation. The corporation's Bingham Canyon mine is generally acknowledged as the world's largest man-made excavation, and the smelter at Magna, Utah, is the largest copper smelter in the world. During each normal year, these facilities produce about 22% of the nation's newly mined copper.

On Thursday, trips have been arranged to the facilities of the Columbia-Geneva Steel Division, U. S. Steel Corporation at Geneva, Utah, the most highly integrated steel mill west of the Mississippi River, and to the Hercules Powder Company at Bacchus, Utah, where work is underway on the third stage of the Minute Man missile and the second stage of the A2 Polaris missile.

Student activities will be concentrated on Thursday. A student luncheon will be held that noon at which a speaker will present a topic of interest to the student participants. This luncheon will be followed by two meetings of students and counselors to discuss problems of mutual interest.

In addition to the technical program, the meeting will include other planned events of general interest. Tuesday evening, there will be a welcoming cocktail party held in the Hotel Utah during the registration period. Wednesday noon, the welcoming luncheon will be held in the Lafayette Ballroom of the Hotel Utah. The featured speaker will be Dr. C. S. Winters of General Motors Corporation. The main banquet of the Pacific General Meeting will be held Thursday evening in the Hotel Utah with a cocktail hour preceding the banquet. There will be entertainment provided after the banquet.

Recreation Facilities Available

Arrangements have been completed with the Salt Lake Country Club whereby AIEE members attending the meeting will be able to utilize the swimming, tennis, and golf facilities of the club at times to be individually arranged.

In addition, there will of course be a ladies program which will start Wednesday morning with a coffee hour. This will be followed by a luncheon and a fashion show to be held at the Fort Douglas Country Club in Salt Lake City. Thursday, there will be a brunch for the ladies at the Log Haven Resort located in Millcreek Canyon near Salt Lake City. The brunch will be followed by bridge and a program on flower arranging for those not interested in bridge.

The Pacific General Meeting is under the joint guidance of H. B. Hodgins, Westinghouse Electric Corporation, and R. A. Radford, Utah Power and Light Company. Requests for information concerning the meeting may be directed to Mr. Hodgins, Westinghouse Electric Corporation, 235 West South Temple, Salt Lake City, Utah.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grade, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N.Y.

Conference Papers Open for Discussion

Conference papers listed below have been accepted by AIEE *Transactions* and are now open for written discussion until June 27. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, AIEE, 33 W. 39th St., New York 18, N. Y., on or before June 27.

60-599	**Locomotive Repair Costs and Their Economic Meaning to the Railways of the United States.** *H. F. Brown*
61-113	**Pole-Zero Techniques Applied to Voice-Frequency Telephone Lines.** *Paul Fleming, Jr.*
61-150	**A Magnetically Regulated D-C to D-C Converter Power Supply.** *Guenter Sager*
61-181	**Noise and Intermodulation Problems in Multichannel Closed-Circuit Television Systems.** *C. A. Collins, A. D. Williams*
61-190	**Contact Wire Wear.** *K. H. Gordon*
61-208	**The Economic Justification of Railway Electrification in the United States.** *H. C. Cross*

Preprints may be purchased at 50¢ each to members, $1.00 to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 W. 39th St., New York 18, N. Y.

ATTENDING the special luncheon during the AIEE Joint District Meeting were: (*standing, left to right*) J. R. Rombach, chairman, AIEE District Meeting; Pie Dufour, columnist, New Orleans *States-Item*, and Walter Criley, vice-president, AIEE District 13. (*Seated*) J. W. Davis, vice-president, AIEE District 4, and W. O. Turner, chairman of the board, Louisiana Power and Light Company.

500 Persons Attend Joint Meeting of South East and South Central Districts

SOME 500 registrants from Districts 4 and 13 met at the Jung Hotel, New Orleans, La., for the AIEE South East and South Central District meeting, held April 5-7.

Among the locations visited on inspection trips during the 3-day meeting were the Avondale Shipyards, the Chalmette plant of the Kaiser Aluminum and Chemical Corporation, the New Orleans Sewerage and Water Board, the Louisiana Power and Light Company's Little Gypsy steam electric station, the Jackson Brewery, and the American Sugar Refineries. In addition, a harbor tow aboard the yacht *Good Neighbor* was planned for members and guests, under the sponsorship of the Celotex Corporation.

Student Paper Awards

A highlight of the meeting was the presentation of student paper awards.

J. W. Davis, vice-president, District 4, presented the awards to District 4 winners. First prize went to W. E. Montgomery, Duke University, for his "Pulse Sampling Video Recording System" and second prize to Lane Scheiber and Ronald Houch, University of Florida, co-authors of "Introduction to Boolean Algebra and Application to NIM Game Logic."

Walter Criley, vice-president, District 13, presented the awards to District 13 winners. First in this District were co-authors W. K. Mitchell and F. L. Treece, University of Alabama, for their paper, "A Receiver-Activated Transmitter Block for Aircraft Radio," and second prize to W. duB. Bringier, Tulane University, for "A Combined-Function AGC Amplifier."

Technical Program Held

The technical program, divided into 15 sessions, covered a large variety of topics, including transmission and distribution, system engineering, shipbuilding, communications, geophysical exploration, commercial, residential, and industrial applications of electricity, instrumentation, substations and switchgear, power generation, and electricity in medicine. An interesting paper in the latter session, by L. M. N. Bach of Tulane University's department of physiology, described the electrical nature of brain activity. He stressed the importance in the electroencephalograph recording procedure of the nature of the pick-up electrodes. These vary considerably, depending upon the level of the analysis desired.

Among the social events at the meeting were a "Welcome to New Orleans" luncheon on the opening day, as well as a hospitality party, and a dinner dance.

The ladies' program featured a "see New Orleans" tour led by professional guides, a special breakfast at Brennan's, and a walking tour of Vieux Carré. At a special ladies' meeting held on Friday, J. G. Adams presented an illustrated lecture on "The Total Electric Home."

L. F. Hickernell Elected to Engineering Foundation Board

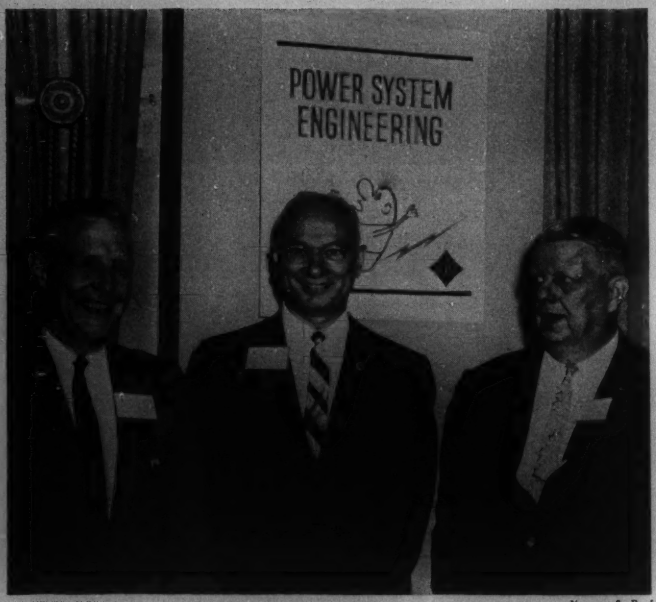
L. F. Hickernell (AM '25, F '34), vice-president—Engineering, for the Anaconda Wire and Cable Company, Hastings-on-Hudson, N. Y., has been elected to a 4-year term on the Engineering Foundation Board by the United Engineering Trustees, Inc.

The Engineering Foundation was established in 1914 by a gift from Ambrose Swasey of Cleveland, Ohio. Its purpose is "the furtherance of research and science and engineering and for the advancement of engineering and the good of mankind."

Mr. Hickernell is a past president of AIEE (1958-59), and has served as AIEE treasurer (1957) and director (1953-57). He is also a member of the British Institution of Electrical Engineers, the American Society for Testing Materials, and the Insulated Power Cable Engineers Association, and is a U. S. National Committee member of the Conference Internationale des Grands Reseaux Electriques.

He received an A.B. degree in mathematics and physics from Grinnell College in 1920 and an S.B. degree in electrical engineering from the Massachusetts Institute of Technology in 1922.

STUDENT paper awards were presented by J. W. Davis (*left*), vice-president, District 4, to W. E. Montgomery (*center*) of Duke University and Ronald Houch of the University of Florida.



Norton & Peel

ATTENDING the Great Lakes District Meeting were: (*left to right*) R. B. Gear, director of the Institute; Fred Bush, vice-president, Great Lakes District, and Dr. W. A. Lewis, director of the Institute.

AIEE Great Lakes District Meeting Held April 19-21 in Minneapolis, Minn.

THE AIEE Great Lakes District Meeting was held at the Pick-Nicollet Hotel on April 19-21 in Minneapolis, Minn. The theme of the meeting was "AIEE D-C to 60 Cycles to Megacycles—Basic Science to Applied Engineering."

This 3-day meeting resulted in a total registration of 401. The program consisted of the presentation of 76 technical papers in 19 sessions, in a range of subjects indicated by the theme of the meeting. The annual student paper competition of the District was held in conjunction with this meeting, and recognition of the winners by Vice-President F. W. Bush was made a special feature of the Friday luncheon.

Winners in Branch Student Paper Contests in the AIEE Great Lakes District schools presented their papers orally on Thursday, April 20. Selection of District Contest Paper Winners was based on this presentation as well as judging of the written entries.

The winners and their papers were:

First Place—J. B. Murphy, Bradley University, for the paper "Solution of Non-Linear Electrical Machine Transients."

Tied for Second Place—P. L. Ranson, University of Illinois, for the paper "Finding the Log-Spiral, A Frequency-Independent Antenna," and L. P. Trubell, Milwaukee School of Engineering, for the paper "Strain Measurements by Employing a Telemetry System."

Honorable Mention—M. Fisher, Northwestern University, for the paper "Equivalent Circuit for a Transister"; Mr. Hopkins and Mr. Creasy, Valparaiso University, authors of "Hoist Control," and T. Kubista, University of Notre Dame, who wrote "The Hall Effect."

C. H. Linder, AIEE president, was the main speaker on the opening day of the convention. Mr. Linder, who is also a General Electric vice-president, spoke on the subject, "New Technology Needs Direction." The complex technology of the modern world is creating a need for increasingly wise management. Coping with the results of new discoveries and applications, Mr. Linder declared, requires skill in weighing alternatives, choosing objectives, and organizing efforts.

"In other words" he said, "technology today requires of us managerial skill of a very high order indeed."

The big need among engineers is to exchange technical information and combine skills "at the working level." It is this kind of working unity at the grass roots where engineering problems are attacked, which technology demands now.

Inspection trips were made to the Lightning and Transients Research Institute and Northern States Power Computer Center, the Electrical Products Laboratory of the Minnesota Mining and Manufacturing Company, the Long Lines Division of the Northwestern Bell Telephone Company, the Electrical Machinery Manufacturing Company and the Control Corporation, the Control Data Corporation, the testing laboratory, Southtown substation, and system dispatching office of Northern States Power Company, the Remington Rand Univac plant, and the Temperature Control Division of the Minneapolis-Honeywell.

The 19 technical sessions included papers on such subjects as science and research, electronic components, transmission and distribution, computing devices, nuclear power, education, instrumentation, communications, power system engineering, digital data-processing systems, and automatic-control theory.

The social program featured a banquet and "Dutch treat" hospitality hour.

SIGNS were an attraction at the Great Lakes District Meeting. Standing beside the signs were: L. W. Christensen (*left*), Cutler Hammer, Inc., publicity chairman, and S. N. Witts, Northern States Power Company, technical program chairman.

5 Engineering Societies Sponsor 2nd Joint Automatic Control Conference

RECENT advances in automatic control will be discussed at the 2nd Joint Automatic Control Conference (JACC), to be held June 28-30 at the University of Colorado, Boulder, Colo. To assure comprehensive coverage of significant progress, five leading societies have provided active sponsorship and programming support—AIEE, the American Institute of Chemical Engineers, American Society of Mechanical Engineers, Institute of Radio Engineers, and Instrument Society of America (ISA).

Attendance of 1,000 control engineers and scientists from the United States and Canada is expected to fill the housing facilities at Boulder. Advance registration and reservation forms for housing and social functions are available from the Meetings Manager, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

The Joint Automatic Control Conference was conceived to avoid duplicate, redundant, and overlapping control meetings. Because this widescale assemblage of control personnel occurs only at the JACC, other related meetings are being scheduled to precede the main forum by 1 and 2 days. Among these ancillary meetings, two are firm:

(1) The Simulation Techniques Subcommittee, AIEE Feedback Control Systems Committee, will conduct a Panel Discussion on Simulation Techniques, Tuesday, June 27. Topics will range from specific techniques, such as simulating samplers and quantizers to simulating broad industrial and economic systems. For details, write to Prof. W. W. Seifert, Massachusetts Institute of Technology, Cambridge 39, Mass.

(2) The Nonlinear Control Theory Committee, AIEE, will organize a Workshop on Dynamic Programming, Tuesday, June 27. Topics will include adaptive control, sampled data, and industrial process control. For details, write to Dr. R. E. Kuba, P.O. Box 3556, Beechwold Station, Columbus, Ohio

Following is the tentative program for the regular JACC sessions:

Wednesday, June 28

Morning Session

Opening Remarks and Welcome—Introductions and Announcements. H. M. Paynter, R. K. Adams, D. A. Rodgers, American Automatic Control Council Award Presentation.

Address: Artificial Intelligence and Automatic Control. Dr. M. L. Minsky, associate professor of mathematics, MIT.

Address: Modern Research in Automatic Control. Dr. Kan Chen, Westinghouse Research Lab.

Afternoon Session
Theory of Optimization

The Structure of Optimum Control Systems. *B. Friedland*

On the Existence of Optimum Controls. *L. Markus, E. B. Lee*

Optimal Pursuit Strategies in Discrete-State Probabilistic Systems. *J. H. Eaton, L. A. Zadeh*

On a Property of Optimal Controllers with Boundedness Constraints. *H. L. Groginsky*

Hydraulic and Pneumatic Control

Design of a Hydraulic Servo with Improved Bandpass Characteristics when Driving a Resonant Mechanical Load. *W. Seamone*

The Linear Properties of Pneumatic Transmission Lines. *N. B. Nichols*

Hydraulic Control of Acoustic-Test Siren Rotors Using Analog-Digital Techniques. *F. D. Ezekiel*

A Systems Approach to High-Accuracy Fluid Control Valving. *R. Henke*

Economic Parameters in Process Control

Cost Models for Systems Engineering. *H. Chestnut*

Outline of the Future Role of Feed-Forward in the Chemical Industry. *S. Calvert, G. Coulman*

Incentives for Computer Control in the Chemical Process Industries. *T. Q. Eliot, D. R. Longmire*

Thursday, June 29

Morning Session
Optimal Switching I

A Switching Criterion for Certain Time-Optimal Systems. *E. R. Rang*

Time Optimal Control of Nonlinear Processes. *E. B. Lee*

A General Iterative Technique for Optimal Control Systems Subject to Saturation. *Yu-Chi Ho*

A Minimal Time Discrete System. *C. A. Desoer, J. Wing*

Aerospace Vehicle Control I

Design Considerations of Inertia Wheel Systems for Attitude Control of Satellite Vehicles. *R. E. Mortensen*

Gyroscopic Coupling in Space Vehicle Attitude Control Systems. *R. H. Cannon, Jr.*

Derived Rate Increment Stabilization: Its Application to the Attitude Control Problem. *J. C. Nicklas, H. C. Vivian*

Process Dynamics

A Finite-Stage Model for Highly Asymmetric Residence-Time Distributions. *R. J. Adler, R. B. Hovorka*

Concentration Dynamics in Tubular Flow Systems. *L. Fan, Y. K. Ahn*

Transfer Functions of Heat Exchangers. *J. P. Hsu, N. Gilbert*

Afternoon Session
Optimal Switching II

Theory and Design of High Order Bang Bang Control Systems. *M. Athanassiades, O. J. M. Smith*

Synthesis of Quasi-Stationary Optimum Nonlinear Control Systems I & II. *P. Chandaket, C. T. Leondes*

Optimal Control Methods for On-Off Sampling Systems. *W. L. Nelson*

Minimum Time Control of Second-Order Pulse-Width-Modulated-Sampled-Data-Systems. *E. Polak*

Aerospace Vehicle Control II

Model Feedback Applied to Flexible Booster Control. *G. E. Tutt, W. K. Waymeyer*

Can Electric Actuators Meet Missile Control Requirements, *G. C. Newton, Jr., R. W. Rasche*

Terminal Control System Applications. *E. A. O'Hern*

Automatic Control Applications

Direct Cycle Nuclear Power Plant Stability Analysis. *D. Buden*

The Application of Dead-Time Compensation to a Chemical Reactor for Automatic Control of Production Rate. *D. E. Lupfer, M. W. Oglesby*

Description of a Digital Speed Regulating System. *J. Dobbie, E. C. Fox*

Measuring and Classifying Haze in Plate Glass with an Automatic Hazemeter. *B. W. Preston*

Friday, June 30

Morning Session
Adaptive Control Systems

A Parameter Perturbation Adaptive Control System. *R. J. McGrath, V. Rajaraman, V. C. Rideout*

Transfer Function Tracking and Adaptive Control Systems. *N. N. Pure, C. N. Weygandt*

Adaptive Servo Tracking. *A. I. Talkin*

An Adaptive 3-Mode Controller for the Process Industries. *W. B. Field*

Nonlinear Control Systems

A Modified Lyapunov Method for Nonlinear Stability Analysis. *D. R. Ingwerson*

Some Recent Advances in Analysis and Synthesis of Nonlinear Systems. *A. A. Wolf*

Nonlinear Controllers. *J. C. Webb, H. T. Bates*

Statistical Design Considerations

Signal Stabilization of a Control System with Random Inputs. *R. Oldenburger, R. Sridhar*

The Use of a Mean Weighted Square Error Criterion for Optimum Filtering of Nonstationary Random Processes. *K. Sahara, G. J. Murphy*

Stability of a Nonlinear Feedback System in the Presence of Gaussian Noise. *R. Sridhar, R. Oldenburger*

A General Performance Index for Analytical Design of Control Systems. *Z. V. Rekasius*

Afternoon Session
Special Topics in Control

On Periodic Modes of Oscillations in Pulse-Width-Modulated Feedback Systems. *E. I. Jury, T. Nishimura*

Design of Noninteracting Control Systems Using Bode Diagrams. *K. Chen, R. A. Mathias, D. M. Sauter*

A Graphical Method for Finding the Frequency Response of Nonlinear Closed-Loop Systems. *A. S. McAllister*

Optimizing Control of Single-Input Extremum Systems. *J. S. Frait, D. P. Eckman*

Sensitivity Considerations for Time-Varying Sampled-Data Feedback Systems. *J. B. Cruz, Jr.*

Process and Control Nonlinearities

Fast Analog Computer Techniques for Design of Controllers for Nonlinear Systems. *G. J. Fiedler, J. J. Landy*

On Stabilization of Feedback Systems Affected by Hysteresis Nonlinearities. *A. K. Mahalanabis*

Stability of Servomechanisms with Friction and Stiction in the Output Element. *F. B. Tuteur*

The Motion of Systems Under Square Law Damping. *W. H. Baier*

Time Series and Process Identification

System Impulse Response Identification Based upon Short Normal Operating Records. *R. Kerr, W. H. Surber, Jr.*

Some Techniques of Linear Systems Identification Using Correlating Filters. *W. W. Lichtenberger*

Digital Computer Analysis of Closed-Loop Systems Using the Number Series Approach. *R. K. Adams*

ADDRESSING the AIEE-sponsored luncheon at the American Power Conference is Sen. G. E. Drach, majority whip of the Illinois State Senate. Seated *(at left)* is C. H. Linder, AIEE president, and *(at right)* W. T. Larner, chairman of the Chicago Section, AIEE.

240 Engineers Attend Rubber and Plastics Conference

The 1961 technical conference of the Rubber and Plastics Industries Committee, AIEE, was held in Akron, Ohio, on April 10-11. Attending the conference were 240 electrical engineers from these industries from all over the country, plus several speakers from England.

The banquet on Monday night was a popular feature of the conference, with 175 persons in attendance, many of them wives of the engineers. A band provided music during dinner and a floor show after dinner.

Technical papers covered the general topics of foreign design, industrial power generation, general applications, and automation. The paper on British vs. American Engineering Practices discussed the basis and history of British design and how and when their standards and practices differed from ours.

A discussion of industrial plant relaying and co-ordination of relays with current limiting fusing in medium voltage starters was the theme of a paper on Co-ordination of Protective Devices in Industrial Power Distribution. The session on industrial distribution, as a whole, encouraged the industrial plant personnel to be more familiar, to take a more active part in the co-ordination of their protective devices, and not to limit their thinking to current relaying.

The paper and discussion on "Speed Regulation by Digital Methods" was received as a possible answer to some particularly tough speed regulating problems in the rubber and plastics industries. A description of the system and accuracies obtainable were offered together with some possible applications.

American Power Conference Holds Annual Meeting in Chicago

The 23rd annual meeting of the American Power Conference, of which AIEE is a co-operating society, was held on March 21-23 at the Sherman Hotel in Chicago, Ill. The meeting broke all previous attendance records with an official registration of 3,016 persons. There were a total of 33 sessions and events comprising 101 papers in all, which covered almost every phase of the power industry.

AIEE was officially represented at the conference by C. H. Linder, president of the Society; J. H. Kinghorn, technical vice-president of the Power Division, and W. T. Larner, chairman of the Chicago Section.

Highlighting the events sponsored by AIEE was the luncheon on Wednesday, March 22, at which Mr. Linder presided. Speaker for the occasion was Illinois Sen. G. E. Drach who spoke on the subject of Federal vs. State Regulation in the Development of Atomic Power.

Other sessions sponsored by AIEE included three sponsored by the Power Division of the Society: high-voltage transmission, automation and control, and system planning and operation, all of which were heavily attended. One other session of special interest to many was devoted to electrical problems of industrial plants. It was sponsored by the Chicago Section of AIEE.

The electrical engineering program was planned by the Electrical Program Committee of which Dr. W. A. Lewis, professor of electrical engineering at Illinois Institute of Technology, and a director of AIEE, is chairman. Director of the conference was Dr. R. A. Budenholzer, professor of mechanical engineering at Illinois Institute of Technology.

Fred Tambling

MUSIC and entertainment were featured at the banquet of the Rubber and Plastics Industries Committee's technical conference in Akron. Kenny Monroe and his Dixieland Band entertained the engineers and their wives.

IFIPS Requests Papers for 1962 Congress in Munich

A call for papers has been issued by the International Federation of Information Processing Societies (IFIPS), which will hold a Congress in Munich, Germany, during August 27-September 1, 1962.

AIEE, together with the Institute of Radio Engineers and the Association for Computing Machinery, is represented in this international federation by the National Joint Computer Committee of these three societies which also holds the Eastern and Western Joint Computer Conferences. AIEE is actively supporting this international Congress.

The Congress will cover all aspects of Information Processing and Digital Computers, which include the following:

1. Business Information Processing—data processing in commerce, industry, and administration.

2. Scientific Information Processing—numerical analysis; calculations in applied mathematics, statistics, and engineering; data reduction; and problems in operations research.

3. Real Time Information Processing—reservation systems, computer control, traffic control, and analog-digital conversion.

4. Storage and Retrieval of Information—memory devices, and library catalogs.

5. Language Translation and Linguistic Analysis.

6. Digital Communication—encoding, decoding, and error detecting and error correcting codes for digital data transmission.

7. Artificial Perception and Intelligence—pattern recognition, biological models, machine learning and automata theory.

8. Advanced Computer Techniques—logical design, logical elements and storage devices; ultrahigh-speed computers, program techniques, and ALGOL.

9. Education—selection and training of computer specialists, training of nonspecialists in the use of computers, and information processing as a university subject.

10. Miscellaneous Subjects—growth of the information processing field.

In each category it is planned to cover, where appropriate, the applications of digital computers, programming, systems design, logical design, equipment, and components.

Those wishing to offer papers are invited to send abstracts of 500 to 1,000 words to: Dr. E. L. Harder, Westinghouse Electric Corporation, East Pittsburgh, Pa., by September 15, 1961. These abstracts will be considered by the international program committee of IFIPS, and authors of selected abstracts will be invited to submit their complete papers, in French or English, for consideration by the program committee in March 1962.

In addition to accepted papers, there will be invited papers, symposia, and panel discussions.

Fox Valley Subsection Hears Engineer's Talk on Stereo

Marvin Camras, senior engineer, Electronics Research Division, Armour Research Foundation of the Illinois Institute of Technology, discussed newest developments in stereo at the April 12 meeting of the Fox Valley Subsection, Chicago Section, AIEE. Mr. Camras' talk included ambiophonic sound and stereo reverberation. He also gave a demonstration of the tape cartridge and automatic changer.

This was the Subsection's "Ladies Night" meeting, held at the Embers Restaurant, near Elgin, Ill.

Another feature of the meeting was the presentation to G. W. Austin of a certificate from the AIEE in recognition and appreciation of his valued services and contributions as Fox Valley Subsection chairman for 1960-61.

Seventy persons attended this meeting, which will be the last to be held by the Subsection until early Autumn.

Western Michigan University Is Host to 7th Pulp and Paper Industry Conference

THE 7th Annual Conference on Electrical Engineering as applied to the Pulp and Paper Industry will be held June 21-23 in the McCracken Hall auditorium on the campus of Western Michigan University in Kalamazoo, Mich. Some 160 ranking electrical engineers from mills and allied industries of widespread areas, including mill electrical engineers from as far north as Canada and as far south as Florida, are expected to attend this conference.

A program of technical papers and timely addresses will be directed at the improvement of technical operations in pulp and paper mills.

Registration

The conference headquarters will be at Zimmerman Hall of Western Michigan University. Reservations will be made available at the new Women's Dormitory of Zimmerman Hall. Double accommodations will be available for couples, and meals will be served in a private dining room at the Student Center. In addition, several convenient motels will be available, such as Kalamazoo Motor Court, Forty Winks Motel, Y-Master Motel, Holiday Motel, Westnedge Hill Motel, Rest Well Motel, Southgate Motel, Burdick Hotel, and Hotel Harris.

Preregistration for this conference is possible by contacting: D. B. Leonardelli, Division of Field Services, Western Michigan University, Kalamazoo, Mich.

Kalamazoo is located in the southwestern part of Michigan, approximately 150 miles west of Detroit and 50 miles south of Grand Rapids. It can be reached by Highway I-94, east and west, and U. S. 131, north and south. It is served by commercial carriers, such as Greyhound Bus Lines, New York Central trains, or North Central and Lake Central Airlines.

A conference booklet containing copies of all papers to be presented will be available at the time of registration.

Sponsors Named

J. M. Yarbrough, of the Mead Corporation, Chillicothe, Ohio, is chairman of the AIEE Paper and Pulp Industry Subcommittee, co-sponsor of the conference. C. L. Eletson, Hopper Paper Company, Taylorsville, Ill., is vice-chairman of the subcommittee and J. S. Kirkland, Rome, Ga., is secretary. Other sponsors of the conference are the West Michigan Section, AIEE, and the Department of Paper Technology at Western Michigan University.

Inspection trips to nearby industrial sites are being planned. A program will be included for any ladies who may be present, with tentative plans including visits Thursday, June 22, to the Upjohn Company's Pharmaceutical Plant, Gibson's, Inc., makers of fine stringed musical instruments, and on Friday, June 23, to the Frontenac Winery, Paw Paw.

A tentative program for the conference follows:

Wednesday, June 21

12:00 noon. Joint Committee Luncheon
AIEE Pulp & Paper Subcommittee; Electrical Engineering Committee, Canadian Pulp & Paper Assn.

6:00 p.m. Preregistration

Thursday, June 22

7:30 a.m. Breakfast
8:30 a.m. Registration
9:30 a.m. Conference Opening
Presiding: D. B. Gearhart, conference chairman, Pulp & Paper Subcommittee

9:30 a.m. Address of Welcome
Dr. G. E. Kohrman, dean of Applied Arts & Sciences, Western Mich. Univ.

Dr. John Fanselow, head, Department Pulp & Paper Technology, Western Mich. Univ.

Presiding: N. L. Heberer, Technical Program

10:00 a.m. Opening Remarks
Chairman: J. M. Yarbrough, Pulp & Paper Subcommittee

Address: Dr. Robert Diehm, Western Mich. Univ. Engineering Developments in Paper Making

11:00 a.m. Data Processing Seminar
Chairman: C. A. Fletchinger, I. P. Pine Bluff.

Techniques in Data Logging—R. P. Derrick, Westinghouse

System Components and Assembly—W. Mikelson, General Elec. Co.

Applications—L. C. Crowder, St. Regis, Jacksonville

12:30 p.m. Luncheon
Chairman: W. L. Sherwood, chairman, AIEE, Western Michigan Section, Consumers Power Co., Grand Rapids

Speaker: Dr. Ward Harrison, president, Allied Paper Corp., Kalamazoo

Afternoon Sessions
Presiding: C. L. Eletson, Hopper Paper Co.

Boiler Flame-Out Control. *P. K. Ryder*, Electronics Corp. of America

The Application of Instantaneous-Trip Circuit Breakers in Motor Control Centers. *W. F. Huette*, Allen-Bradley Co.

5:30 p.m. Social Hour
Ladies included.

7:00 p.m. Banquet
Toastmaster: A. A. Southon, retired chairman of the Board and director emeritus, K.V.P. Sutherland Co., Kalamazoo.

Speaker: Rice Kello, zone manager, Investors Division Services, Evansville, Ind.

Friday, June 23

7:30 a.m. Breakfast

9:30 a.m. D-C Motor and Generator
Panel Moderator: J. S. Kirkland, Rome Kraft Co.

Panel Members: J. Ewing, Reliance Elec. & Engr. Co.; P. T. Schuerman, General Elec. Co.; A. G. Posluszny, Westinghouse Elec. Corp.; W. Stiffler, Olin Mathieson Co.; H. Murdock, Allis-Chalmers Co.

12:15 pm. Lunch

1:15 p.m. Mill Tours
Sutherland Division, K.V.P. Sutherland Co.,

to see: Paper board making and carton converting.

K.V.P. Division, K.V.P. Sutherland Co., to see: Specialty paper making and specialty paper converting.

Individual tours for anyone interested can be arranged to any of the Kalamazoo valley paper mills.

Ladies Program

A tentative program of ladies' activities follows:

Thursday, June 22

9:45 a.m. Visit Upjohn Company, Portage Plant
One of the largest pharmaceutical plants in the world.

12:30 p.m. Lunch
Schensul's Cafeteria, Kalamazoo.

2:00 p.m. Visit Gibson's, Inc.
Makers of fine stringed musical instruments.

At 5:00 p.m., ladies will assemble in the lobby of Zimmerman Hall for transportation to the Social Hour, followed by a banquet.

Friday, June 23

9:30 a.m. Tour of Frontenac Winery, Paw Paw

12:15 p.m. Lunch

The administrative officers of Western Michigan University are as follows:

Dr. J. W. Miller, president; Dr. G. E. Kohrman, dean, School of Applied Arts and Sciences; Dr J. R. Fanselow, head, Department of Paper Technology, and Otto Yntema, director, Division of Field Services.

Advisory Committee To Recommend Action on NBS High Voltage Laboratory

FOR almost 20 years, the National Bureau of Standards (NBS) has maintained in Washington, D. C., a High Voltage Laboratory as part of the Electricity Division. This laboratory has been concerned with precision measurements of high voltages —both alternating and direct—and phase angle at high a-c voltages. The facilities of this laboratory have not been used to their full capacity. It is probable that this difficulty is due as much to the lack of appropriate demands from industry as it is to any other cause. The personnel of NBS has been aware of the needs of extending accurate measurements facilities to higher voltages, but they have not received sufficient encouragement and support from industry so that they could devote adequate effort and time to this activity.

Not Feasible To Allocate More Space

In view of the fact that industry has not made any great demands on the laboratory, it was felt by NBS that it would not be feasible to allocate greater space in the new facilities the Bureau is planning at Gaitherburg, Md., to the high-voltage facility than had been available at the present site in Washington. With the growing interest of the power industry into ever higher voltages, it was apparent that a laboratory incapable of increasing the voltage range above that now available would be inadequate to meet the needs of the ever increasing voltages, and it was concluded that it was not justifiable under present conditions to move the High Voltage Laboratory to the new location.

Since the present land must be converted to other uses when NBS leaves it, it is not feasible to maintain the present laboratory as it is now; therefore, either a new High Voltage Laboratory must be built or the present facilities abandoned when the move is completed in about 4 years.

For several years, the National Research Council of the National Academy of Sciences, at the request of NBS, has provided a series of advisory panels to give advice regarding its activities to each of the Divisions of the Bureau. When the proposal to abandon the High Voltage Laboratory was presented to the advisory panel of the Electricity Division, the panel questioned the appropriateness of the tentative decision to abandon the laboratory. With this in mind, the advisory panel recommended that a special Ad Hoc Advisory Committee be appointed by the National Research Council to consider the needs for a NBS High Voltage Laboratory and to make specific recommendations to the Bureau as to its future course of actions.

Ad Hoc Committee Named

The personnel of the Ad Hoc Committee is as follows: J. T. Lusignan, chairman, J. R. Meador, S. B. Smith, P. H. McAuley, W. S. Price, E. C. Starr, and W. A. Lewis (ex officio), who is representing the Division advisory panel. The personnel of the Electricity Division advisory panel is: W. A. Lewis, chairman, N. I. Adams, W. G. Amey, R. M. Bozorth, J. G. Brainerd, H. B. Linford, Ernst Weber, and J. T. Lusignan.

Comments from interested persons and organizations would be welcomed by the Ad Hoc Advisory Committee on any phase of the activities. Comments may be sent to Dr. J. T. Lusignan, vice-president, Ohio Brass Company, 380 North Main St., Mansfield, Ohio, or to Dr. W. A. Lewis, Illinois Institute of Technology, Chicago 16, Ill.

Dean Stoker Receives Fellow Certificate

PRESENTATION of an AIEE Fellow certificate was made by Lawrence Grew (*right*), chairman of the AIEE Connecticut Section, to Dr. W. C. Stocker (*left*), dean of the Hartford Graduate Division, Rensselaer Polytechnic Institute, at the Section's April 4th meeting in Old Lyme, Conn. Approximately 60 members attended the meeting.

R. K. Jurgen Appointed Associate Editor of Institute

R. K. Jurgen, formerly editor of *Industrial Electronics*, has joined the AIEE publications staff as associate editor.

Mr. Jurgen was born January 12, 1927, in New Britain, Conn., and was graduated from Rensselaer Polytechnic Institute, Troy, N. Y., with the B.S. degree in electrical engineering (electronics option) in 1950. During World War II, he served in the U.S. Navy as an electronic technician's mate. Other positions held previously by Mr. Jurgen include: editor, *Electronic*

Equipment; feature editor, *Electronics;* manager of scientific information, International Business Machines Corporation, and assistant editor, AIEE publications.

Mr. Jurgen is a member of AIEE (application pending) and a senior member of the Institute of Radio Engineers (IRE). He is serving currently as Technical Program chairman for the AIEE-IRE-ISA (Instrument Society of America) 1961 Industrial Electronics Symposium.

Student Branch Charter Given by San Francisco Section

A Student Branch Charter was presented by the AIEE San Francisco Section to the officers and advisers of the newly formed Joint Student Branch at San Francisco State College. Taking part in the presentation ceremonies, which took place at the Section's April meeting, were: Prof. T. J. Zilka, head of the Engineering Department, San Francisco State College; R. B. Marxheimer, assistant professor of electrical engineering and student counselor, and Student Branch officers. Noel Shirley is president of the Student Branch; William Owens, vice-president; Alfred Giannel, treasurer, and Fred Nase, Electronics Committee chairman.

H. N. Skow, chairman of the San Francisco Section, in making the presentation, outlined the expanding interest of the Institute and the San Francisco Section in the affairs of the Student Branches and pledged assistance and encouragement from the Section membership for the new Branch at San Francisco State College. He went on to explain several new programs initiated by the Section for the Student Branches this year under the Student Relations Committee chairmanship of Edwin Fleischmann.

Student Branches within the San Francisco Section now total seven in number, including the University of Santa Clara; Stanford University; San Jose State College; U. S. Navy Postgraduate School, Monterey; University of California, Berkeley, and University of Nevada.

Col. Kintner Addresses Philadelphia Section on Strategy

Col. W. R. Kintner of the U. S. Army spoke on "A Forward Strategy for the United States" when he addressed 175 members and guests of the Philadelphia Section, AIEE, at the Section's March 13 meeting.

A West Point graduate, Col. Kintner is currently assigned to the chief, research and development, Department of the Army, on a special project with the Foreign Policy Research Institute at the University of Pennsylvania. In his talk at the Section meeting, he appraised the serious long-term challenges posed to the United States by Communist imperialism, nationalist and socio-economic revolt in Afro-Asia, the technological revolution, and the spectre of warfare in the nuclear age. He followed this with a proposal for the adoption of certain long-range policies and strategies for dealing with these problems as they will confront this country in the decade of the '60s.

THE Student Branch Charter for the newly formed San Francisco State College Branch was presented by H. N. Skow *(left)*, chairman of the AIEE San Francisco Section, to Prof. T. J. Zilka *(center)*, head of the college Engineering Department, and Prof. R. B. Marxheimer, student counselor.

Another feature of the Section meeting was the presentation by Section Chairman R. L. Halberstadt of Fellow certificates and certificates in recognition of services by prominent Philadelphia area engineers in recognition of their services to the AIEE on a national level.

Fellow certificates were presented to the following: Dr. R. C. Machler, director of the research and development department, Leeds and Northrup Company; J. W. Jones, senior engineer, Electrical Engineering Division, engineering department, Philadelphia Electric Company; A. J. Williams, Jr., science advisor, research and development department, Leeds and Northrup Company, and Dr. W. R. Clark, manager of the Product Engineering Division, engineering department, Leeds and Northrup Company.

PROMINENT Philadelphia area engineers were recipients of certificates in recognition of their services to AIEE on a national level. The certificates were presented at the March 13 meeting of the Philadelphia Section to the following: *(left to right)* Dr. W. R. Clark of Leeds and Northrup Company, AIEE Finance Committee chairman (1958-60); A. C. Hartranft of Philadelphia Electric Company, chairman of Administrative Subcommittee, System Engineering Committee (1959-60); D. C. Hoffman of General Electric Company, Conversion Substation Subcommittee (1958-60), and E. B. Curdts of James G. Biddle Company, Special Instruments and Auxiliary Apparatus Committee chairman (1959-60). The presentation was made by R. L. Halberstadt *(right)*, Section chairman.

Section Holds Prize Paper Competition

AMONG those authors participating in the Annual Prize Paper Competition at the Cleveland Section's March meeting were: *(left to right)* H. H. Koppel, Bailey Meter Company; E. W. Downer and C. M. Shuster, Cleveland Electric Illuminating Company, and G. Pinter, Jack & Heintz Company. Mr. Pinter won first prize for his paper, entitled "An A-C Electric Transmission Drive for Turbine Powered Vehicles."

Electrical-Electronics Firms Invited To Participate in Engineering Exposition

FIRMS representing every phase of the electrical-electronics industry have been invited to participate in the first industry-wide national Electrical Engineering Exposition.

The Exposition, sponsored by AIEE, will be held January 29-February 2, 1962, at the New York Coliseum in New York City.

Manufacturers of equipment and those firms providing materials and services in the electrical-electronics field received their invitations from the Reber-Friel Company of Philadelphia, Pa., nationally known exposition management concern in charge of the Exposition.

Coincides with AIEE Winter Meeting

The invitation, signed by H. F. Grebe, exhibits manager, pointed out that the Electrical Engineering Exposition will be held in conjunction with the Annual Winter General Meeting of the AIEE. A technical program featuring some 27 sessions will be held in meeting rooms adjacent to the exhibit areas.

AIEE has more than 55,000 members and 117 affiliated local groups. N. S. Hibshman, executive secretary of AIEE, said the decision to hold the Exposition was made when a survey of the AIEE membership attending last year's Winter General Meeting showed that the majority of the engineers and scientists definitely want exhibits of electric products and services to supplement the AIEE technical sessions.

"The Exposition," stated Mr. Grebe in his letter of invitation, "thus offers a company an unequalled opportunity to display its products and services to high-level executives, engineers, and scientists who make up the membership of the AIEE."

Mr. Grebe added that space will be assigned on a first-come first-served basis. He said the entire first and second floors of the New York Coliseum have been reserved for the Exposition.

The invitation to participate in the Exposition was accompanied by a specially prepared Blue Book showing how the event is being planned to meet the many and varied needs of the electrical-electronics field.

"The electrical industry," the Blue Book states, "is unique in its cross-breeding of ideas. One segment uses the products and services of another, which, in turn, produces equipment or techniques for still another. It is through this continuous cross-breeding of ideas among the innumerable subdivisions of the industry that new developments are perfected and electrical growth stimulated.

"The Electrical Engineering Exposition is custom-built to facilitate this intra-industry exchange of ideas. It has also been developed to supplement and enhance the full range of the educational and scientific value of the technical sessions of the AIEE Winter General Meeting.

"The AIEE alone, of all technical societies in this country, encompasses the generation and distribution of electric power and its utilization in industry, controls, communications by wire and radio, are in space."

'Horizontal Exposition'

The Blue Book goes on to explain that the AIEE event will be "A horizontal, across-the-board Exposition" in that it will display the many products and services of "every branch of the industry." It also points out that the Exposition will feature several hundred different categories of electric-electronic equipment, materials, and services—everything from accelerators to feedback controls, from microwave systems to xerographic processes.

The keynote of the Exposition, the Blue Book adds, will be electricity and electronics. Its key figure will be the electrical engineer—"interested in the advancing technology of the industry and eager to keep abreast of the great range and swift pace of developments in the field of electrical engineering."

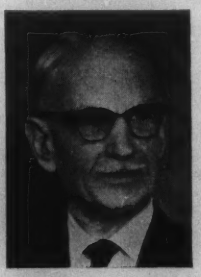
A copy of the Blue Book, detailed information about the Electrical Engineering Exposition, and floor plans of the exhibit areas in the New York Coliseum may be obtained from the Reber-Friel Company, 117 S. 17th St., Philadelphia 3, Pa.

M. A. Wilson of Kansas Is Elected President of NSPE

M. A. Wilson, a consulting engineer of Salina, Kans., has been elected president of the National Society of Professional Engineers (NSPE).

Mr. Wilson, who established the consulting firm of Wilson & Company in 1941, holds engineering degrees from Kansas State University and an honorary doctor's degree from Kansas Wesleyan University. He has served as president of the Kansas Engineering Society and the Kansas Section of the American Society of Civil Engineers. He has also been a member of the ECPD (Engineers' Council for Professional Development) Engineering College Accrediting Committee for Region V, the Kansas State College Research Foundation, and the Governor's Advisory Committee on Flood Control.

Mr. Wilson has served as chairman of a



M. A. Wilson

number of NSPE committees, and is a past chairman of the NSPE Board of Ethical Review. He holds membership in the American Institute of Consulting Engineers, the American Water Works Association, the American Public Works Association, and the American Road Builders' Association.

Six area vice-presidents, one of which is an AIEE member, and a treasurer were also elected by the 56,000-member engineering group for the administrative year which will begin in July. The new vice-presidents are: W. E. Christian, New Brunswick, N. J.—Northeastern Area; H. F. Pierce (AM '39, M '49), Miami, Fla.—Southeastern Area; W. W. Wegner, Cedar Rapids, Iowa—North Central Area; C. R. Hanes, Columbus, Ohio—Central Area; T. T. Mann, Roswell, N. W.—Southwestern Area, and J. H. Stufflebean, Tucson, Ariz.—Western Area. R. B. Allen, Silver Spring, Md., was elected treasurer.

Fire Protection Expert Speaks on Fire Alarm Systems

L. T. Chandler, technical products manager for Edwards Company, Inc., Norwalk, Conn., addressed the Power and Industrial Division of AIEE on April 4 in New York. The subject of Mr. Chandler's talk was "Commercial and Industrial Fire Alarm Systems.

A nationally recognized fire protection expert, Mr. Chandler is a member of the Signaling Committee of the National Electrical Manufacturers Association, a senior member of the Western Society of Engineers, and has served on the Codes Committee of the National Fire Protection Association. He has authored numerous pieces on fire protection for leading technical publications, among them *Architectural Record* and *Progressive Architecture*.

Canadian Societies Sponsor Lectures

Ken Davies

MONTREAL Sections of AIEE and the Illuminating Engineering Society (IES) worked together recently to present a 7-lecture series on Illumination. Pictured at Hydro-Quebec's Service Centre in Montreal, Que., Canada, are: (*left to right*) C. Labrecque, committee chairman, educational and student activities, IES; A. Dandenault, board of managers, IES; H. O. Wilson, chairman, Montreal Section, AIEE, and A. J. Hanley, chairman, Montreal Section, IES.

The general topic of the lecture series for 1961 of the Power and Industrial Division of AIEE has been "Design of Electrical Systems for Modern Buildings." Talks by experts in such fields as lighting, circuits, code requirements, etc., have been included in the 11-lecture series.

AIEE PERSONALITIES

P. A. Abetti (AM '49, M '55) has been promoted to manager of the General Electric Company's Electrical Engineering Laboratory in Schenectady, N. Y. He was formerly manager of Project EHV, General Electric Company, Pittsfield, Mass. Mr. Abetti has served on the following AIEE Committees: Basic Sciences (1953-61), Volta Scholarship (1959-61, chairman 1960-61), and Professional Development and Recognition Department (1960-61).

J. F. Armstrong (AM '44, M '45) has been named vice-president of El Paso Electric Company. In his new capacity, Mr. Armstrong will be manager of the Mesilla Valley Division with offices in Las Cruces, N. Mex. He was formerly general engineer for the company.

A. C. Bayle (AM '41) has been appointed staff engineer, technical operations, at the Mitre Corporation, Bedford, Mass. Initially, Mr. Bayle's responsibilities will be in the area of systems planning. Prior to joining Mitre, Mr. Bayle was vice-president and director of engineering for the Waltham Precision Instrument Company, Waltham, Mass.

J. C. Beckett (AM '40, M '49) has been elected president of the Palo Alto Engineering Company, Palo Alto, Calif. Mr. Beckett is also general manager of the firm. He has served on the following AIEE Committees: Electrical Techniques in Medicine and Biology (1955-61, chairman 1958-60) and Science and Electronics Division (1958-61).

J. J. Bednarz (AM '39, M '51), formerly Polaris technical director and currently assistant director of research, Lockheed Missiles and Space Division, Sunnyvale, Calif., has been awarded the Navy Meritorious Public Service Award for his key role in developing the Navy's Polaris fleet ballistic missile 3 years ahead of schedule.

L. V. Berkner (AM '29, F '47), newly elected president of the Institute of Radio Engineers, will be guest speaker at the banquet of the Institute of Radio Engineers' Canadian Electronics Conference in Toronto, Ont., Canada, on October 3. Dr. Berkner will speak on "Progress Through Electronics." He is now president of Associated Universities, Inc., New York, N. Y.

H. C. Blair (AM '50) has been appointed manager of the Phoenix District, Industries Group, Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Mr. Blair had been manager of industrial sales in Allis-Chalmers' New Orleans District since 1959.

A. H. Canada (M '48) has been named manager of engineering for Raytheon Company's Santa Barbara Operations. Mr. Canada was most recently a technical consultant on infrared and optical techniques for the Advanced Research Projects Agency. He has served on the AIEE Electronics Committee (1949-61).

J. W. Harte, Jr. (M '60) has been named Service Division manager of Daystrom Inc., Weston Instruments Division, Poughkeepsie, N. Y. In his new position, Mr. Harte will be responsible for the field service operations of the Poughkeepsie plant line of recorders, controllers, and gauge products. Mr. Harte joined Daystrom in 1958.

Robert Hautzik (AM '50) has joined the Microwave Laboratories of Quantatron, Inc., Santa Monica, Calif., as manager of microwave engineering. He was formerly chief engineer of Airtron, Inc.

J. C. Walter (M '42), manager, High Power Electronics and Nucleonics Engineering, Radio Corporation of America, Camden, N. J., was recently cited by Lt. Gen. G. W. Mundy, U. S. Air Force, commandant of the Industrial College of the Armed Forces, for having completed the college's correspondence course with honors. The course, entitled "The Economics of National Security," is based on the 10-month resident course conducted for selected senior officers of the military services as well as officials of the civilian governmental agencies. Mr. Walter is a captain in the U. S. Navy Reserve.

H. H. Weber

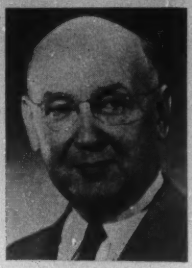
H. H. Weber (AM '27, F '40) has retired from Kaiser Aluminum & Chemical Sales, Inc., after serving the electrical industry for almost half a century. Recently, Mr. Weber had been a consulting engineer with the company's Electrical Conductor Division at the Newark, Ohio, plant. Prior to joining Kaiser Aluminum in 1957, he was general sales manager of the electric wire and cable department for the U. S. Rubber Company where he served for 23 years. Mr. Weber also held responsible positions with the General Cable Corporation for more than 12 years.

R. A. Williamson (AM '36, M '50), formerly manager of railroad locomotive marketing, has been named manager of export locomotive sales of the General Electric Corporation, Schenectady, N. Y.

OBITUARIES

Ernest de Marchena (AM '03, Member for Life), engineer of the arts and manufactures, and honorary professor of the Central School of Arts and Manufactures at Paris, France, died recently. Mr. de Marchena also served as president, Société des Forces Motrices de la Vienne. He was born in 1868. His employment included an engineering position with a French company.

Hilding Ferdinand Gidlund (AM '35, M '42, F '60), superintendent of the electrical distribution department, Public Service Company of Colorado, Denver, Colo., died recently. Born July 10, 1902, in Haparanda, Sweden, Mr. Gidlund had been associated with Public Service since 1929. He served the company as a design engi-



H. F. Gidlund

neer, substation engineer, superintendent of substations, deputy superintendent of electric distribution, and at his death held the position of superintendent of distribution. Mr. Gidlund served on the following AIEE Committees: Substations (1948-57), Membership (1955-57), and Sections (1957-58).

Arthur Williston Henshaw (AM '06, M '07, F '13, Member for Life), a retired executive of the General Electric Company, Schenectady, N. Y., died recently at the age of 88. Born August 19, 1872, in Easthampton, Mass., he graduated from Lehigh University in 1894. He entered the employ of General Electric at Schenectady in the testing department and subsequently was a member of the engineering and manufacturing general departments. In 1903, Mr. Henshaw was named a commercial engineer in the power and mining department. A few months later, he went to the Stanley Electric Manufacturing Company's works at Pittsfield, Mass., which later became the Pittsfield works of General Electric. Returning to Schenectady in 1901, Mr. Henshaw joined the General Electric engineering department and later the induction motor and manufacturing general departments. In 1925, Mr. Henshaw was transferred to the commercial general department, and a few years later was placed in charge of all General Electric association relationships. He was a member of Tau Beta Pi.

William Osmun Kyte (AM '33, M '47), advertising and sales promotion manager for General Electric's Apparatus Sales Division in the company's Pacific Southwest District, died recently. Mr. Kyte was born June 4, 1911, in Minneapolis, Minn., and studied at the University of Kansas from which he received the B.S. degree in electrical engineering in 1932. He joined General Electric's test engineering program in 1934 in Schenectady, N. Y. The following year, he became a lecturer at General Electric's Research Laboratory in Schenectady, and in 1937, was placed in charge of sales, engine driven generators, Motor Division. He was transferred to Los Angeles, Calif., in 1938 as a sales and application engineer for the apparatus department. In 1942, he joined the U. S. Army Signal Corps and that year had assignments at Harvard University's Cruft Laboratory and the Radiation Laboratory at the Massachusetts Institute of Technology. He participated in 6 campaigns in the European Theater of Operations beginning in 1943, and in 1945 went to Wright Field as a radar design and development officer. Discharged honorably as a captain, he received the Presidential Unit Citation and a Bronze Star Medal. Mr. Kyte returned to General Electric in 1946 to assume the position he held until his death. He was a member of the Institute of Radio Engineers, the Pacific Coast Electrical Association, and Kappa Eta Kappa, and was a registered engineer in the State of California.

Joseph Chester Langdell (AM '07, M '37, F '47, Member for Life), meter authority of Jackson, Mich., died February 5 at the age of 74. Mr. Langdell was associated with Commonwealth Services Inc. and its predecessor companies from 1917 until his retirement in 1951. At the time of his retirement, he was in charge of all Commonwealth meter consulting activities. He was born February 8, 1886, in Salem, Mass.

Gordon Hunter Needham (AM '41, M '50), engineer, Defense Activities Division, Western Electric Company, New York, N. Y., died April 4. Before joining Western Electric in 1955, he worked with the New Jersey Bell Telephone Company, Newark, N. J., in various engineering positions for more than a quarter of a century. Born October 1, 1903, in Clinton, Mass., he was educated at Brown University from which he received the B.S. degree in electrical engineering in 1926. Mr. Needham was employed by the New York Telephone Company in 1926 in the engineering department of its New Jersey territory, which became a part of the New Jersey Bell Telephone Company the following year. He served in the U. S. Navy during 1942-45, assigned to the Radio and Electrical Branch of the Bureau of Aeronautics, Navy Department. Mr. Needham was a past chairman of the New Jersey Division of AIEE.

Eugene Clinton West (AM '53), assistant division electrical engineer, Public Service Company of New Hampshire, Laconia, N. H. Born September 24, 1923, in Kingston, N. H., he received the B.S. degree in electrical engineering in 1949 from the University of New Hampshire. Mr. West was employed by the company 11½ years ago, first in Manchester, and then as assistant electrical engineer for the Central Division in Laconia.

Joseph Densmore Wood (AM '19, M '27, F '56, Member for Life), consultant—power equipment, I-T-E Circuit Breaker Company, Philadelphia, Pa., died March 11 at the age of 66. Born November 30, 1894, in Wichita, Kans., he received B.S. degrees from Guilford College in 1915 and from Haverford College in 1916, and the M.A. degree from Haverford the following year. Mr. Wood was formerly chief engineer and president of Roller-Smith Company, and was employed by the Westinghouse Electric Corporation, General Electric Company, and Condit Electric and Manufacturing Company. He held more than 75 United States and foreign patents. Mr. Wood served on the following AIEE Committees: Protective Devices (1937-45), Switchgear (1947-61, chairman 1954-56), and Power Division (1954-56).

OF CURRENT INTEREST

THE Bell System's experimental satellite communications ground station near Rumford, Maine, eventually may look like this (*right*). Artist's conception shows a central control building surrounded by five "radome"-covered antennas. The horn antenna to be built this year for satellite communications tests is at lower left. Second antenna will be needed to maintain uninterrupted communications as one satellite "sets" below the horizon and another "rises." Third would take over during maintenance. Fourth and fifth would communicate with some overseas point not linked by the first pair.

World's Largest Horn Planned as Part of Space Communications Ground Station

WORKMEN are clearing parts of a 1,000-acre tract in western Maine near Rumford—about 75 miles by road from Portland—where the Bell System will install the world's largest horn as part of a new experimental space communications ground station.

The horn, a highly sensitive antenna designed and developed by the Bell Telephone Laboratories, will be ready by early next year.

It will do two things: (1) beam signals to a satellite, which will relay them to Europe, and (2) serve as a giant ear trumpet to scoop up faint signals that are relayed back from Europe by way of the satellite.

The 250-ton steel and aluminum structure will be a rotating antenna—177 feet long, 94 feet high. It will be protected from wind and weather by the largest inflated earthbound structure ever made.

Its spherical cover, or "radome," supported by air pressure, will be 210 feet wide, 161 feet high—about as high as a 13-story building. It will enclose about twice the space of the seating area in New York's Radio City Music Hall. The radome is designed to weather the strongest anticipated gales. Its skin will be 20 tons of synthetic rubber and fabric $\frac{1}{16}$ inch thick which would cover 3 acres if laid out flat.

All this will be a major step toward linking the countries of the world with telephone, data, and television channels via satellites.

Constituting the most advanced complex of facilities in the space communications field, the $7 million station will be built on a site about 10 miles northwest of Rumford. Bell engineers and scientists will conduct experiments there.

Rumford's antenna will be an enlarged version of the horn antenna at Holmdel, N. J., which was used successfully for Project Echo. However, the Rumford antenna will provide nine times as much antenna surface.

The Rumford area offered several advantages:

It is far from routes of microwave radio relay stations that operate on the same frequency bands to be used for the satellite experiments. Because signals from satellites are very weak, they are especially vulnerable to interference from signals in the same frequencies—even those considered weak by ordinary standards.

Topographically the site is well suited. It is a broad, saucer-shaped hill only 900 feet high and ringed by mountains up to 3,800 feet high that help block off stray radio interference from other areas. The mountains are not so high that they will block communications with satellites. Also, the site is near a highway.

In moving to the Rumford site, the Bell System has no intention to abandon the Holmdel, N. J., ground station. Much remains to be done in the space communications field, and basic research will continue at Holmdel.

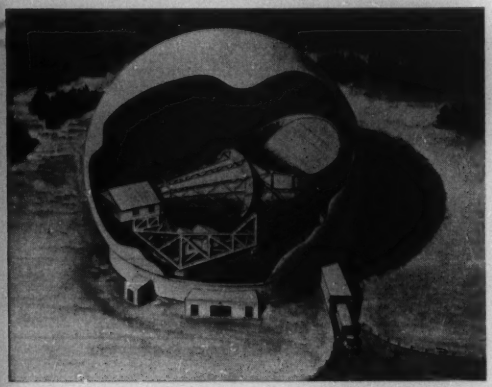
From Rumford, the company will conduct experimental transatlantic space communications co-operating with telephone administrations abroad. These tie in with Bell's plans for a satellite communications system. The company feels such a system is necessary because of the growing need for overseas communications of all kinds and to furnish alternate routes for reliability.

Space communications systems are a natural supplement to and extension of existing common carrier networks. The Bell System handled 4 million overseas telephone calls in 1960. And the volume is growing at the rate of about 20% each year. A satellite system would enable Bell to provide not only telephone, but also high-speed data and live television channels overseas.

The American Telephone & Telegraph Company (AT&T) has announced that its proposed system would use from 30 to 50 satellites to link, eventually, countries all over the world. It has offered to pay the government the cost of experimental satellites and their launching. Cost of operating the system would be paid by the Bell System and telephone organizations of other countries, just as they now share costs of undersea cables.

After the Rumford station is used for experiments, the Bell System hopes to use it for commercial traffic.

Although specific sites for ground sta-



ARTIST'S cut-away drawing shows how the antenna will be protected from the weather by the largest inflated "radome" yet made, 210 feet across and 161 feet high. People and even trucks will enter the dome through air locks, to keep it from deflating. The dome will be made of synthetic rubber and fabric that is "transparent" to radio waves.

BELL Telephone Laboratories engineer A. O. Schwarz checks model of the "world's biggest horn" which will be built this year near Rumford, Maine. The antenna, 177 feet long and housed in a "radome" 210 feet across and 161 feet high, will be used for experiments in sending television and high-speed data as well as telephone calls across the Atlantic by way of satellites. The horn rotates on two circular tracks and also turns about its horizontal axis.

tions in other countries have not been announced, the British plan to have one in the British Isles and the French and West German communications administrations plan to take part.

AT&T has assured the National Aeronautics and Space Administration (NASA) that the Rumford facilities will be made available for NASA's experimental use.

EE

New Element Discovered By Scientists at AEC

Discovery of an isotope of element 103 was announced recently by a team of scientists at the Lawrence Radiation Laboratory, operated for the Atomic Energy Commission (AEC) by the University of California.

The Berkeley researchers have suggested the name Lawrencium (chemical symbol Lw) for the new element in honor of the late Ernest O. Lawrence, Nobel prize winner, inventor of the cyclotron and founder of the laboratory which now bears his name.

The discovery was made by nuclear chemists Albert Ghiorso, Torbjorn Sikkeland, A. E. Larsh, and R. M. Latimer of the Lawrence Radiation Laboratory. A paper on the research, which was supported by the U.S. AEC has been sent to the *Physical Review* for publication.

The scientists performed their experiments with the heavy ion linear accelerator (HILAC), one of the major tools of nuclear research at the Lawrence laboratory.

First evidence for the creation of the element 103 isotope was achieved on February 14, 1961. The following 2 months were spent in confirming the February results. Attempts to create element 103 span almost 3 years; the final 6 months were devoted to especially intensive experimentation.

The element 103 isotope is the first to be discovered solely by nuclear methods. No chemical techniques were used.

The new element was created by bombarding a target consisting of 3 millionths of a gram of Californium (element 98) with boron 10 or boron 11 nuclei having energies of about 70 million electron volts (mev).

The Berkeley scientists deposited Californium over an area $\frac{1}{10}$ inch in diameter on a nickel foil having a thickness of 50 millionths of an inch. This target fuel was enclosed in a container filled with helium and placed in front of the highly concentrated beam of the HILAC.

When a Californium atom captured a beam nucleus, a new nucleus was instantaneously formed, several neutrons came off and the resulting nucleus flew out of the target. This nucleus was slowed down by colliding with helium atoms and was attracted to a thin copper conveyor belt. The belt was periodically pulled a short distance to place the collected atoms of element 103 in front of a series of silicon crystal detectors.

The silicon detectors recorded a maximum of five events per hour in which alpha particles of 8.6 mev were emitted by atoms of element 103. No attempt was made to identify the resulting daughter atoms of Mendelevium (element 101).

Final proof of the presence of element 103 was made through a series of experiments which ruled out the possibility that isotopes of element 102 or element 101 might have produced the 8.6-mev alpha particles. The half-life (the period in which half of a given quantity of an isotope will decay into another element) of the 103 isotope was determined to be about 8 seconds.

The new 103 isotope is thought by scientists to have a maximum atomic weight of 257 (total number of protons and neutrons in the nucleus), although further research will be required before this can be established conclusively.

The scientists pointed out that the actinide concept, elucidated by Dr. G. T. Seaborg, University of California nuclear scientist who is now chairman of the U. S. AEC, indicates that element 103 should be the last of the actinides to be discovered. The actinide series consists of 15 elements with atomic numbers 89 through 103, all of which have similar properties. Element 104 should have chemical properties different from those of all the preceding transuranium elements.

According to one scientific theory, element 103 is a "dinosaur" of matter, which was formed at the birth of the universe, but decayed out of existence in a matter of weeks following creation.

The discovery of element 103 shows no promise of direct practical application, but will broaden man's fundamental understanding of matter and its properties.

Since 1940, University of California scientists have discovered or participated in the discovery of 10 synthetic elements heavier than uranium—from neptunium, element 93, through element 102, the discovery of which was reported in 1958. The list includes the important atomic energy fuel, plutonium, element 94.

EE

Future Meetings of Other Societies

EEI, 29th Annual Convention, June 5-7, New York, N. Y. Edison Electric Institute, 750 Third Ave., New York 17, N. Y.

International Instrument-Automation Conference and Exhibit, June 6-8, Royal York Hotel, Toronto, Ont., Canada. H. S. Kindler, Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

NEMA, First Western Conference, June 8, Biltmore Hotel, Los Angeles, Calif. Russell Gingles, Dir. of Public Rel., National Electrical Manufacturers Association, 155 E. 44th St., New York 17, N. Y.

Electrical Apparatus Service Association, 28th Annual Convention, June 11-14, Jack Tar Hotel, San Francisco, Calif. National Industrial Service Association, Inc., 7730 Carondelet Ave., St. Louis 5, Mo.

9th Annual Technical Writers' Institute, June 12-16, Rensselaer Polytechnic Institute, Troy, N. Y. Prof. J. R. Gould, Rensselaer Polytechnic Inst., Troy, N. Y.

Institute of Radio Engineers

Professional Group on Product Engineering and Production, June 14-15, Sheraton Hotel, Philadelphia, Pa.

Chicago Professional Group on Broadcast and Television Receivers, Spring Conference, June 15-16, O'Hare Inn, Des Plaines, Ill.

5th National Convention on Military Electronics, June 26-28, Washington, D. C. IRE, 1 E. 79th St., New York 21, N. Y.

ASA Seminar on Industrial Standardization, June 19-23, Engineering Societies Building, New York, N. Y. K. G. Ellsworth, PR, American Standards Association, 10 E. 40th St., New York 16, N. Y.

8th Annual Symposium on Computers and Data Processing, June 22-23, Elkhorn Lodge, Estes Park, Colo. W. H. Eichelberger, Denver Research Institute, University of Denver, Denver 10, Colo.

ASHRAE, 68th Annual Meeting, June 26-28, Denver Hilton Hotel, Denver, Colo. American Society of Heating, Refrigerating and Air-Conditioning Engineers, 234 Fifth Ave., New York 1, N. Y.

Overseas

The Chemical & Petroleum Engineering Exhibition, June 20-30, Olympia, London. Adrian Seligman, Engineering in Britain, 9 Malcolm Road, London, S. W. 19, England.

IMEKO Conference, June 26-July 1, Engineering Societies Building, Budapest, Hungary. J. Johnston, Jr., President of ISSA, Dupont de Nemours, Wilmington 98, Del. or IMEKO Secretariat, Budapest 5, P.O.B. 3.

United Nations Conference on New Sources of Energy, Aug. 21-31, Rome, Italy, A. G. Katzin, Executive Secretary, United Nations Conference on New Sources of Energy, United Nations, New York, N.Y.

Rassegna Internazionale Elettronica, Industrial and Commercial Exhibit, Aug. 21-31. Via della Scrofa 15, Rome. (Organized by "Rassegna"—not United Nations or the Italian Government). Same.

Third International Conference on Analog Computation, Sept. 4-9, Belgrade, Yugoslavia. Yugoslavia Committee for ETAN, Terazije 23/VII, Belgrade, Yugoslavia.

Rotary Transformers Developed To Replace Slip Rings and Brushes

ROTARY transformers that supply power to and extract signals from rotating mechanical structures without direct physical contact have been developed at Instrumentation Laboratory, Massachusetts Institute of Technology (MIT), to replace conventional contact-type slip rings and brushes.

The transformers, since they eliminate sliding contacts, are literally frictionless current transfer devices and, as such, could have a host of applications in electrical design and engineering.

For instance, rotary transformers could be used to eliminate slip rings in synchronous electric motors and thus extend motor life. Or sets of rotary transformers could supply power to and extract signals from gimbals in a variety of electromechanical attitude reference systems, such as autopilots, thus greatly reducing input and output uncertainties. Rotary transformers could be used in frictionless devices such as those which might be used to test satellite vehicles under conditions simulating the environment of space.

Laboratory test data thus far has indicated that devices using no-contact rotary transformers in place of contact-type slip rings and brushes exhibit greater reliability, have longer operating life and longer shelf life, are plagued with less noise in low-level circuits and less wear in high-level circuits, and require less torque to turn the rotating member, whatever it may be.

The rotary transformer technique, developed by R. L. Gibson, Woburn, Mass., a Laboratory research engineer, is based on the principle of physically separating the primary portions of the transformer from the secondary portions by a small air gap, freeing the halves to rotate with respect to one another.

When the primary portion is fixed to one structure and the secondary to another, the magnetic flux, set up by current in the primary winding, passes from the primary portion of the magnetic circuit, through the air gap, and into the secondary portion of the magnetic circuit, inducing current in the secondary winding. The flux courses through the complete magnetic circuit via the air gap uninterruptedly, even when one structure —and, hence, a half of the transformer— rotates with respect to the other.

Magnetic circuits in the rotary transformers are fabricated from ferrite compounds because of the ease with which these materials can be handled, shaped, formed, and ground.

Size, shape, and geometry of a rotary transformer depends on the job it is designed to do. To pass current into a rotating structure, the primary half of the transformer is fixed to the nonrotating case or frame and the secondary portion to the structure itself. Just the reverse is true to extract current from the rotating structure.

Sets of rotary transformers can be stacked along an axis of rotation in cases where the length of the shaft is not particularly limited by other factors. In this case, primary portions of the transformers are arranged concentric to the secondary portions and complete transformers are arranged axially with respect to each other.

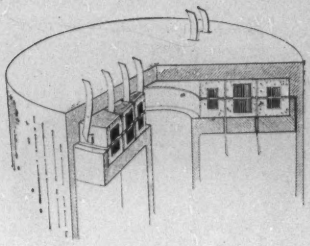
In cases where shaft length is limited, sets of rotary transformers can be arranged in concentric circles around a particular point on the axis of rotation. Here, primary and secondary portions of each transformer are formed in equal size rings and positioned so that each primary portion is mutually opposed to its respective secondary portion. Complete transformers are arranged radially with respect to each other.

Both axial and radial rotary transformers have been built and tested at Instrumentation Laboratory.

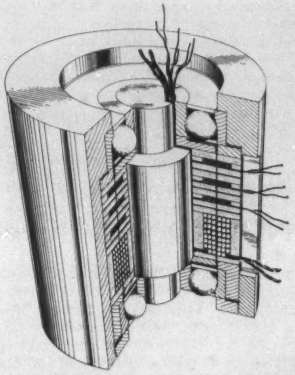
Ferrite rings and cup cores which make up the magnetic circuits are custom formed for any particular transformer design. Primary and secondary portions of the transformers are initially assembled separately in metal holders. Epoxy resin is used to adhere primary and secondary windings to their respective ferrite portions of the magnetic circuits.

Finishing grinding, however, is performed on fully assembled transformer units in order to avoid variations due to eccentric rotations. As a result, MIT rotary transformers have shown less than 0.1% change of amplitude with rotation due to eccentricities in the finished rings. Grinding is done on conventional surface and cylindrical grinders with tolerances of 1/10,000th of an inch throughout.

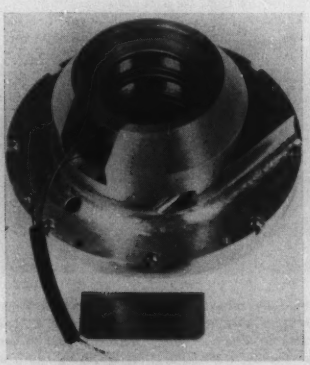
Rotary transformers are not as efficient from a power standpoint as slip rings and brushes, but they can be made with efficiency adequate for many useful applications. For instance, prototype rotary transformers built at the Laboratory were designed to a specification of 98% power



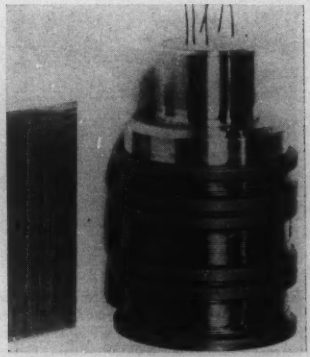
A rotating device which uses three radial-type power transformers with primary (upper) and secondary (lower) portions arranged in mutually opposing rings. With limited space along the shaft, sets of transformers can be arranged concentrically around a point on the axis of rotation.



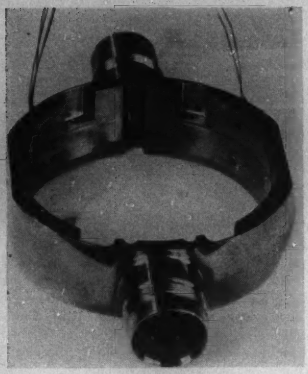
A rotating device, showing an axial-type rotary power transformer (*far right*) and three axial-rotary signal transformers. With ample space along the axis of rotation, primary and secondary portions of the transformers are arranged concentric to each other and stacked along the shaft.



Fixed primary portion of an axial-type rotary power transformer.



Rotating secondary portion of an axial-type rotary power transformer.



◄ A rotating structure with the primary portion of axial-type rotary signal transformers mounted along shaft.

efficiency, a requirement that was easily met.

Although they must be assembled, ground, and mounted with extreme care and precision, rotary transformers in finished form are extremely rugged. Several were accidentally dropped to the floor—some as many as three times each—during the MIT studies without performance impairment. Even if the ferrite structures which make up the magnetic circuits crack in a radial direction, performance is not affected.

Instrumentation Laboratory developed the rotary transformer technique as part of an over-all research project aimed at reducing problems associated with the use of slip rings and brushes in pendulous integrating gyro accelerometers such as those used in inertial navigation and guidance systems for ships, airplanes, missiles, and space vehicles. Primary interest of the Laboratory, which is headed by Dr. C. S. Draper, professor and chairman of the Department of Aeronautics and Astronautics at MIT, is in the design and development of these systems. Test data indicates that rotary transformers can be used in place of slip rings to provide gyro accelerometers with wheel power, microsyn excitation current, torquing current and output signals proportional to angle and temperature. **EE**

SPASUR Helps Provide NORAD with "Eyes" in Space

THE Space Surveillance Facility (SPASUR) is operated by the U. S. Navy as a part of the North American Air Defense Command (NORAD) Space Detection system. SPASUR, together with the Air Force-operated SPACETRACK facility and Ballistic Missile Early Warning System (BMEWS) make up the team that provides NORAD eyes in space and a capability to detect, track, and catalog all man-made objects placed in space.

SPASUR was developed by the U.S. Naval Research Laboratory to detect, track, and predict the orbits of nonco-operative or hostile satellites passing over the United States, in response to an order from the Advanced Research Projects Agency. In late 1960 the system reached a point in its development where its definite operational capability had been demonstrated. It was assigned to the operational control of NORAD in November 1960 and thus became a part of this country's aerospace defense system.

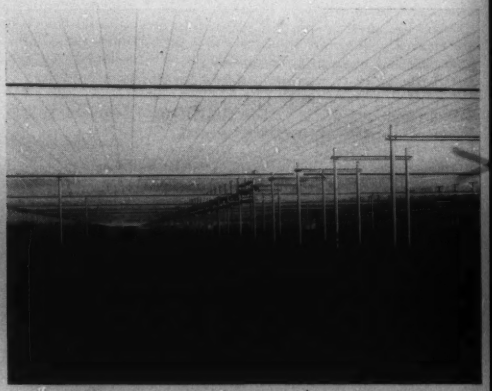
The Space Surveillance Facility consists of three functional subsystems. The first consists of a detection network, the second is a tracking and prediction center equipped with a high-speed digital computer, and the third, known as SPASCORE, displays the present, past, or future paths of known satellites in orbit. The two latter subsystems are located at Dahlgren, Va.

The detection and surveillance network consists of two complexes: the eastern and the western. Each complex consists of two 108-mc receivers separated by about 500 miles and a 50-kw transmitter located equidistant between the receivers. The transmitter sends out a continuous wave of radio energy in a pattern very narrow in the north–south direction and wide in the east–west direction. The receivers have similar antenna patterns and all are coplaner with the transmitter pattern, so that when a satellite enters the transmitter antenna pattern it is also entering the antenna pattern of the two receivers. The two receivers then receive the reflected energy from the satellite as it crosses through the antenna patterns.

The receiving stations are equipped with the necessary equipment to measure in a very precise manner the direction from which the satellite reflections arrive at each station.

The data describing these precise directions is then transmitted automatically over a high-quality telephone circuit to the Space Surveillance Operations Center at Dahlgren for processing.

The receivers for the eastern complex



MEMBERS of the staff of the Naval Weapons Laboratory (above, *left*) face the Naval Ordnance Research Computer (NORC), a talented electronic item that assists in the operation of the North American Air Defense Command (NORAD) Space Surveillance Facility, (SPASUR). NORC is situated at Dahlgren, Va., and is utilized as part of the Space Surveillance Control Center also located there. SPASUR, together with the USAF-operated SPACETRACK facility and Ballistic Missile Early Warning System, make up the team that provides NORAD eyes in space and a capability to detect, track, and catalog all man-made objects placed in space. SPASUR is operated by the U. S. Navy as part of NORAD's Space Detection system. Above, *right:* A geometric ground view of the Space Surveillance Receiver antenna array. This array is 1,600 feet in length and 300 feet in width.

Official NORAD photos

are located at Fort Stewart, Ga., and Silver Lake, Miss. The transmitter is located about 18 miles north of Montgomery, Ala. A similar complex is located in the western part of the United States. The two receivers are located at the Naval Air Station, Brown Feld, near San Diego, Calif., and at Elephant Butte, near Truth or Consequences, N. Mex. The transmitter for this complex is located at Gila River, near Phoenix, Ariz.

The gap in the Navy silent satellite detection system stretching across the southern part of the United States is being plugged in 1961 by one of the world's largest transmitters. The 560,000-watt device—to be built under U.S. Naval Research Laboratory direction 35 miles southwest of Wichita Falls, Texas, near Archer City—will be five times as powerful as the largest television transmitter and will feed one of the world's longest antennas.

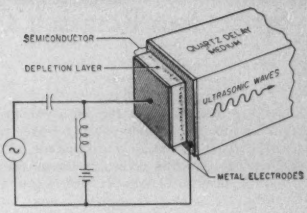
The addition being built in north central Texas will serve to increase greatly the range of the system by increasing the signals reflected to each receiver. At present, the receivers in one complex normally receive only signals reflected by their own transmitter. With this larger transmitter, reflected signals may be received at all four receiving stations simultaneously.

The data from all four receiving stations is received at the SPASUR Operations Center, Dahlgren, at the same instant the satellite passes through the antenna pattern. At the present time the data is read visually, interpreted, and inserted into the NORC computer for orbit determination and satellite predictions.

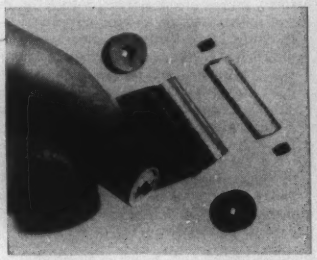
Within the near future it is expected that the data will be automatically inserted from the transmission line into the computer without ever having been interpreted or even handled by a human being.

As a satellite repeatedly crosses the line in successive revolutions, the computer accumulates these observations and continually refines the orbital elements stored in the computer memory or Space Catalog. As the difference between the observed passage and the predicted passage decreases to an acceptable level, the computer will automatically store future observations and recompute the orbital elements or predictions only when the observed accumulated error drifts beyond the acceptable maximums.

While operational control of the system has been transferred to the North American Air Defense Command, additional research and development of the system will be done under the direction of the Naval Research Laboratory. Management control of the system will be exercised by the Bureau of Naval Weapons. **EE**



SCHEMATIC DIAGRAM of Bell Telephone Laboratories depletion layer transducer attached to a quartz crystal. The depletion layer forms in the piezoelectric semiconductor at the interface between the semiconductor and a thin metal electrode. Electric signals applied to the layer are converted to ultrasonic waves. The accompanying circuit also controls the thickness of the depletion layer.



EXPLODED VIEW of an ultrasonic delay line using two Bell Telephone Laboratories depletion layer transducers. Small blocks of piezoelectric semiconductor (gallium arsenide), with thin metal films deposited on their surfaces, are bonded to the ends of a 1-inch-long quartz crystal which serves as the delay medium.

New, High-Frequency Ultrasonic Transducer Developed

A NEW, efficient device for converting electric energy into ultrasonic energy and vice versa at microwave frequencies was described recently by D. L. White of Bell Telephone Laboratories. The new device is a piezoelectric transducer utilizing a semiconductor depletion layer. It is expected to be employed primarily in ultrasonic delay lines where its operation at high frequencies and wide bandwidths will make it possible to store large amounts of information.

Another possible use will be as a tool for studying the acoustical properties of materials at higher ultrasonic frequencies. It is anticipated that large amplitude ultrasonic waves can be generated in materials at microwave frequencies and also extremely weak waves can be detected with greater efficiency than with existing transducers.

The new Bell Laboratories transducer consists of a plate of piezoelectric semiconductor (such as gallium arsenide) on which a thin metal film is deposited. The film constitutes a nonohmic rectifying contact which causes a depletion layer to form. (A depletion layer is a thin region of high resistivity that forms at the interface of two dissimilar materials such as a p-n junction in a semiconductor or a rectifying metal-to-semiconductor contact. The difference in Fermi levels of the two adjacent materials usually gives rise to an internal electric field which sweeps or "depletes" the thin interface region free of mobile charge carriers, thereby increasing its resistance.) The thickness of the depletion layer can be controlled with a negative bias voltage across the interface.

When an a-c voltage is applied, most of the voltage drop occurs across the layer and the layer behaves in a manner similar to a very thin piezoelectric crystal which is bonded to a solid. Since the layer is thin, 10^{-3} to 10^{-5} cm, the electric field is very large and considerable piezoelectric stress can be produced in the layer.

The depletion layer transducer has several advantages over an ordinary transducer:

1. Because the layer is so thin, the greatest efficiency of the transducer is at very high frequencies. Current models operate at under 1,000 mc but the frequency range is expected to be extended to above 10,000 mc. In this high-frequency range, this transducer should be as much as one hundred times more efficient than any other known transducer. With a highly efficient transducer, small electric signals can generate ultrasonic waves and very weak ultrasonic waves can be detected.

2. The thickness of the layer, hence the resonant frequency of the transducer can be varied by varying the d-c bias voltage. This adds great flexibility to its use. (Conventional piezoelectric transducers do not have this feature.)

3. Present models measured at 600 mc have a bandwidth of 5% (30 mc), an order of magnitude larger than typical ceramic transducers, operating at frequencies below 10 mc. This means that a comparable increase should be expected in the amount of information which can be transmitted. It is expected that, with operation at higher frequencies, even wider bandwidths can be achieved.

4. The transducer is relatively simple to make and easy to handle.

Up to now, the use of ultrasonic delay lines at high frequencies has been limited because ultrasonic waves could not be generated or detected efficiently at microwave frequencies, and furthermore, were considerably attenuated in the delay material. Now, however, the higher efficiency of the depletion layer transducer makes up for these losses and makes possible delay lines having longer delay times. This, with the large bandwidth characteristic, will enable large amounts of information to be stored.

In experiments at Bell Laboratories, the new depletion layer transducers operated well at frequencies as high as 830 mc. It is expected that improvements in circuit and fabrication techniques will greatly extend the frequency range. **EE**

Space-Age Research Center

A $14 million home for the creation of generations of manned space vehicles was unveiled recently at Farmingdale, L.I., N.Y., by Republic Aviation Corporation.

Built around a complex of seven advanced research laboratories and supported by a trio of wind tunnels, this 3-level Research and Development Center already has design groups at work on plans for manned vehicles ranging from aircraft twenty times the speed of sound to lunar reconnaissance spaceships.

The Center, dedicated in memory of Paul Moore, one of the founders of the 30-year-old company, is believed to be the most diversified privately owned facility of its type. Officials said it has the built-in capability of developing complete astronautical systems. Much of the equipment had to be specially built; for example, the hydrogen gun to study meteorite impact, the big space-simulation chamber, and the anechoic (echo-free) chamber. All these are unique from either a design or capability point of view.

Alexander Kartveli, vice-president for research and development, said the Center is the hub of a broad-scale expansion of research activity which began in 1958 and has since taken the company's scientists and engineers into more than 29 new technological areas.

SPACE-FLIGHT conditions more than 150 miles up can be simulated in this 30-foot-long altitude chamber, a major "tool" of Republic's Space Environment and Life Sciences Laboratory. This is said to be the only unit of its size capable of simulating such altitudes. It tests not only man but also complete space systems and capsules.

He cited the names of the laboratories as an index of the type of activity underway. They are: Space Environment and Life Sciences, Re-entry Simulation, Materials Development, Nuclear Radiation, Guidance and Control Systems, Fluid Systems, and Electronics. In addition a hypersonic wind tunnel is being completed. This, together with the existing transonic and supersonic tunnels and a high-velocity shock tube in the laboratory gives Republic the capability of testing aircraft or space models in simulated flight conditions from Mach 0.6 (400 miles an hour) to over Mach 25 (19,500 miles an hour) or orbital speed, Mr. Kartveli said.

He pointed out that the accelerated pace of technical progress has had the net effect of increasing not only industry's responsibility for new concepts and for more versatile and capable weapons, but also for feasibility and operational analy-

THIS 12-inch optical flat mirror (above, *left*) is part of an advanced testing instrument known as an autocollimator. Over 15 feet long, the instrument provides a parallel beam of light 16 inches in diameter for use by scientists in Republic Aviation Corporation's Guidance and Control Laboratory. With it they test the functioning and accuracy of optical systems both in the visible and infrared portions of the spectrum. The tests are part of developmental work for gyro-stabilized star-tracking systems. Above, *right:* A metallized re-entry vehicle model is readied for radar reflection testing in Republic's uniquely shaped anechoic (echo-free) chamber in the Electronics Laboratory in the new Research and Development Center. The chamber is equipped with a remotely controlled turntable (at base of styrofoam tower) and automatic instruments for measuring radiation patterns. In this particular test being set up the radar cross-section is determined by means of radar waves bounced off the model in various positions to determine the angles of maximum and minimum reflection.

ses. This requires manpower and facilities of scope and dimension surpassing any previous needs.

To measure up to such exacting standards, it was explained, Republic's Research Center was planned by its scientists and engineers after nationwide conferences and surveys with the nation's top authorities in various fields. In all, more than 100 leading scientists and engineers in 51 companies, 21 government agencies, and a dozen colleges and universities were consulted.

Dr. W. J. O'Donnell, chief engineer for Applied Research and Development, explained that the fundamental role of each laboratory in the Center is to support corporate-wide activity in two fields of research being pursued simultaneously: in aeronautics and in astronautics.

As a result of such planning Republic is at work on new versions of military aircraft ranging from types designed to take off from short runways (STOL) and vertical rising models (VTOL) to the highly secret "space plane" and, simultaneously, is at work on designs of orbital re-entry and lunar exploration space vehicles, he explained.

The Center, which is located in the southeast corner of the company's 530-acre tract, was more than 2 years in construction. It currently houses more than 400 scientists and engineers (approximately 25% of the total technical staff at Republic), of which 150 have advanced degrees, Mr. O'Donnell said. He pointed out that they are primarily specialists in such fields as life sciences, medicine, solid-state physics, thermodynamics and aerodynamics, psychology, physiology, nuclear physics, radiology, metallography, astronomy, and chemical engineering.

Its power requirements, equal to those needed to satisfy the electrical load of a city of 10,000, is supplied by 20 tons of generators and related equipment and fed to the laboratories by some 80 miles of wiring.

The lower level houses a scientific reference library valued at more than a quarter of a million dollars. It subscribes to technical journals from all over the world, including a dozen Soviet publications which are regularly translated.

Among the more unusual scientific "tools" built into the various laboratories are: a 96-foot hypervelocity shock tube capable of producing conditions found at Mach 20 and a light gas (hydrogen) gun which fires projectiles at speeds of 26,000 mph to simulate meteoroid impact, both in the Re-Entry Simulation Laboratory; the electron beam furnace and ultrasonic welding units of the Materials Development Laboratory; two "hot" cells armed by 40,000 curies of cobalt 60, one of the largest isotope sources in the industry, located in the Nuclear Radiation Laboratory; a complex array of such specialized equipment as crystal orientation instruments, vacuum ultraviolet and infrared spectrophotometer, a collimator (to provide a simulated star source to test tracking instruments,) and two vacuum coaters used in thin film research, all incorporated in the Guidance and Control Systems Laboratory; the Fluid Systems Laboratory's 15-foot 3-chambered oven for testing hydraulic systems under space environment conditions; the uniquely shaped anechoic chamber and the electrically shielded room in the Electronics Laboratory, the former to measure radiation patterns, the latter to evaluate sensitive airborne electronic systems; and the huge, 30-foot-long space simulation chamber in the Space Environment and Life Sciences Laboratory, said to be the only unit of its kind capable of simulating altitudes of more than 150 miles above earth to test both men and complete space systems and capsules. **EE**

Antennas for Detecting Micropulsations

Special-purpose antennas for investigating micropulsations in the earth's magnetic field have been designed and constructed by the National Bureau of Standards (NBS). These loop antennas, each 6½ feet in diameter and containing 32,000 turns of nylon-coated copper wire, will be used by Dr. W. H. Campbell of the Bureau's Central Radio Propagation Laboratory, Boulder, Colo., to collect data on the behavior of micropulsations and to discover how they can be related to unusual manifestations of solar or magnetic activity. Results of this program, only recently begun, are expected to provide further useful information about ionospheric disturbances arising from extraterrestrial sources which may affect radio communications.

Oscillations of the earth's magnetic field may be divided into three general period groups: (1) the giant pulsations, often observed on standard magnetometer records, which generally have periods of about 1 to 3 minutes and amplitudes reaching 10 or so gamma; (2) micropulsations with oscillation periods ranging from 5 to 30 seconds and with amplitudes reaching several gamma; and (3) oscillation periods in the range 0.5 to 3 seconds, which appear more rarely than the other two groups, with amplitudes occasionally reaching 1 gamma. The outstanding features of the three groups are their nearly sinusoidal form and the fact that the group characteristic periods and average amplitudes both decrease roughly by powers of ten.

On the rim of each loop antenna, in four separate channels, is wound 130 miles of copper wire. The copper wire is covered by a layer of copper screening, and finally the whole antenna is coated with Fiberglas for protection and waterproofing. This protection is necessary because the antennas will be buried in the earth to prevent interference from wind action. Sensitive enough to respond to faint, ultra-low-frequency electromagnetic waves or micropulsations, the antennas will be used to study oscillations in the broad range of periods from 200 to 0.1 second which can be observed on a world-wide basis.

The signals now under most intensive study by the Bureau are the oscillations of from 5- to 30-second periods. These micropulsations have been known to the scientific world since 1861, but little is understood about their origin or why the oscillations occur as they do. It is known that the signals are much stronger in the auroral zones and that they are probably associated with the influx of primary electrons into the ionosphere after the occurrence of solar storms.

Permanent micropulsation installations, using one antenna each, are being established near Boulder, Colo.; College, Alaska; and Huancayo, Peru. Six additional antennas will be used in the future to equip two portable stations where re-

Donald Wasmundt supervises the winding of one of the nine 6½-foot-diameter loop antennas which the National Bureau of Standards will use to study micropulsations in the earth's magnetic field. These pulsations, of very small amplitude, can have periods ranging from 0.1 to 200 seconds.

search will be conducted to measure and define the direction of micropulsations over broad areas.

Although the antennas will be used primarily in the study of micropulsations, they will also be of value in the study of two other types of electromagnetic waves —extra low-frequency sferics, which originate from lightning discharges, and 1- to 3-minute giant pulsations which are thought to be caused by the resonance of the outer atmosphere when bombarded by charged particles from the sun. **EE**

IRE Holds Annual Convention

The Institute of Radio Engineers (IRE) held their annual convention at the Waldorf-Astoria Hotel, New York, N. Y., March 20-23, 1961. The 4-day program of technical papers and exhibits at the Coliseum drew engineers from 40 countries who heard and viewed material that ranged the spectrum of electronic technology. Highlight of the program was a special symposium at which seven of the nation's top authorities discussed "New Energy Sources."

Some of the highlights at the exhibit were:

Thermoelectric generator. Burns propane gas that heats hot junction to 450 C; cold junction kept at 125 C by natural convection cooling. Uses special solid-state unit in junction and delivers 40 watts, sufficient to run an *HO* model train.

Household applications of transistors. Unique developments include low-cost capacitive switch that operates when hand approaches, light dimmer for incandescent lamps, electric-range and electric motors controls.

Rubidium frequency standard. A device using atomic resonance of rubidium vapor as a reference to control electronic circuits which has long-term stability of one part in ten to the tenth power. Prototype has flown in missiles.

High-speed camera. Capable of taking a sequence of three pictures at a frame rate of 20-million a second. This camera is electronically operated on image-converter principle.

High-power tube for BMEWS. A 10-foot-tall 870-pound tube delivering 1¼ megawatts of power used in Ballistic Missile Early Warning System (BMEWS), 500 of these tubes are on order for BMEWS.

Desk-size video tape recorder. Compact unit, using 96 transistors, features new tunnel diodes in memory head.

Electronic ignition systems. Incorporates electronic principles and components. This approach provides an exceptionally reliable spark for internal combustion engines.

Electronic needle threader. Unique application of tape programming in a system that employs newly synchronous motor and pulse-to-step translator. Speeds up to 225 or 400 steps per second possible.

Light-frozen motion. Coin spinning at high speed, stopped optically by a strobotac. **EE**

Fast-Acting Automatic Checkout Equipment for Missiles

Engineers at Convair (Pomona) Division of General Dynamics Corporation have developed universal checkout equipment that reduces the cost of missile production, yet increases reliability.

Called PDQ (for Programmed Data Quantizer), the equipment checks electrical and hydraulic missile guidance systems.

The key element is a combination unit that both programs the tests to be performed and converts the results into digital information for read-out on typewriter or printer.

Before, engineers have had a choice of testing missile guidance systems by tedious manual methods, or by designing automatic checkout equipment to perform specific tests.

The old automatic equipment reduced labor costs and, in general, improved reliability through elimination of human error. But such systems are expensive and limited. Even a minor design change in the missile obsoletes test equipment worth thousands of dollars.

Convair's universal test stand combines the speed and reliability of automatic equipment with the versatility of a manual operation. The total cost for checkout equipment is reduced to a fraction of the previous cost because the test units can be moved easily throughout the plant to do all kinds of jobs.

A basic PDQ unit with accessories can be built for less than $50,000. A specialized system with approximately the same capabilities costs up to $200,000, and could become obsolete through a change in missile design.

The PDQ receives its instructions from a paper tape listing each of the tests to be performed. The tape also controls the conditions of voltage and current under which the test is being made. To change a test sequence, engineers simply prepare a new taped instruction and feed it into the PDQ.

The development of a variety of modules was essential to the design of the universal equipment. The modules include power supplies, signal generators, comparators, data storage units, and other elements that would be compatible with each other and with the basic PDQ unit.

They are assembled rapidly in various combinations, according to need, through simple cable connections. By following this building-block scheme, engineers can call for a test installation of almost any complexity, and assemble it from parts off the shelf.

Each PDQ element is capable of handling up to 400 test points and scanning them at a rate of up to four points a second. The readout may be in numerical order from 1 to 400, or in any other sequence selected by the program tape.

At the same time, the tape specifies through an external programmer the value of the electrical inputs used to energize the circuits under test.

The effect is exactly as if a test operator were applying various voltages to a section of the missile guidance control system to simulate various flight conditions, and reading the results.

The tape also can be used to decide whether the circuit under test meets specifications. The correct value for each test is included in the taped instruction, and this is compared to the actual reading. An alarm system calls any discrepancies to the attention of the test engineer, either by blinking a light or printing the off-specification data in red.

The result of each test is an electrical signal that is then converted into decimal information by a digital converter within the PDQ. The accuracy of this conversion is better than 99.9%, providing the test engineer with an exact, easy-to-read value for evaluation and records. The digital information can be stored as a typewritten record, a perforated paper tape, or a stack of punch cards. If necessary, this information can later be fed into a computer for further processing and evaluation.

The PDQ approach to missile testing is of particular value in plants such as the Convair-Pomona facility, where several missiles of various sizes and configurations have been developed and produced.

Convair-Pomona originally was organized to produce the Terrier missile for the

FOLLOWING test instructions coded on paper tape, this equipment automatically checks out missile components in the Pomona, Calif., plant of Convair Division, General Dynamics Corporation. The part under test here (on console shelf, right) is a gas pressure system. The equipment makes four tests per second, prints the results, alerts the operator to any malfunctions detected, and turns itself off.

Navy. This work has evolved into production of the Advanced Terrior and Tartar for the Navy, and development of the Mauler for the Army. In addition, the plant is developing the new Redeye missile for Army and Marine Corps. EE

Jetway Solves Jet-Age Problem With Radicon Speed Reducer

One Jet-Age problem, speeding passengers on and off huge jetliners, is being solved daily in airports from coast to coast by a unique "Jetway" telescopic corridor manufactured by P. I. Steel Corp., Ogden, Utah, subsidiary of Stanray Corp. Extending like a telescope, the self-powered Jetway seals itself against an aircraft, providing direct connection with the terminal and protecting passengers from noise and weather.

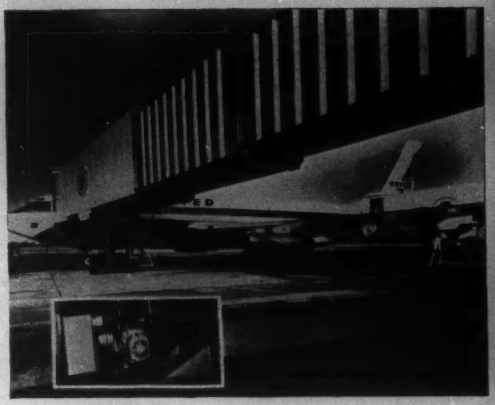
However, in the course of solving that problem, P. I. Steel came up with one of their own: How to assure safe, accurate leveling of the ramp to meet planes of varying heights. This answer was found in a new "Radicon" worm gear reducer recently marketed by Foote Bros. Gear & Machine Corp.

P. I. Steel designed a belt-driven take-off from the elevator motor used to raise and lower the telescopic corridor. They used this take-off to power a Foote Bros. model *A112* Radicon reducer which, in turn, drives a 10,000-ohm rheostat. The rheostat controls an electrical meter at the operator console, visually indicating actual height of the Jetway.

"Great accuracy in height indication was attained by controlling the rheostat with a speed reducer," a P. I. Steel spokesman states. "Our Jetway system can now accommodate planes whose doors range in height from 6 feet 8 inches to 13 feet 6 inches, including the DC-6Bs, DC-7s, DC-8s, and Boeing 720s used by United Airlines at their new Seattle Terminal."

The Radicon unit was selected because of its 40/1 gear ratio, a major factor in assuring accuracy of the height control system, plus other factors of price, design, and performance characteristics.

Some 23 Jetway "comfort corridors" using the variable height feature have been installed as well as many more with a standard height when only one type of plane is used. Newest additions will be 16 at the Los Angeles airport this Spring, with 15 more scheduled for Chicago's O'Hare Field by the end of 1961. EE



P. I. STEEL CORP. encountered a special problem in adjusting their "Jetway" telescopic corridors like the one here, to the height of different jetlines. As a solution, they coupled a Foote Bros. "Radicon" worm gear reducer to a 10,000-ohm rheostat *(inset)*, then hooked the rheostat to an electrical meter at the operator console to indicate visually actual height of the Jetway corridor.

100-Mw Power Supply Unit Installed To Test Tubes

An electrical facility powerful enough to throw a searchlight beam well beyond the moon has been installed by Sperry's Electronic Tube Division at Great Neck, N. Y., to test the capabilities of high-power amplifier klystrons which Sperry develops and produces for advance radar and guided missile systems.

Part of an extensive tube-manufacturing facility now in operation at the Long Island electronics plant, the unit can deliver a peak power of 100 million watts at 270,000 volts.

Representing an investment of $1 million, the facility's 4,000 square feet are divided into two sections. The section housing the power supply unit is referred to as the "nonliveable area" because of its lethal electrical output. Walls 8 inches thick, further protected by metallic shields, prevent any of the electrostatic charges from escaping into the second section of the facility—the "liveable area"—where operators and controls are located.

First step in the testing process takes place when the tube is assembled in an ultraclean room where temperature, humidity, and dust are rigidly controlled to ensure against any microscopic particles hampering the tube's performance.

A traveling crane then lifts the assembled tube and lowers it into a "vacuum bake-out oven" where it is subjected to temperatures up to 1,100 F for 12 hours. This helps guarantee a near-perfect vacuum within the tube—a condition equivalent to 200 miles out in space.

After this stringent processing, the tube is placed in a high-voltage cage where controlled electrical discharges are applied to vaporize any minute irregularities on its surfaces that might cause trouble later.

The tube is now ready to pass the most severe part of the test in the main section of the power supply unit—a lead-lined steel tank 16 feet long and 10 feet high. Partially immersed in 3,000 gallons of special oil to ensure maximum insulation, the tube undergoes tests to demonstrate its multimillion watt power output capabilities at specific frequencies. In the nonliveable area, a maze of transformers,

SCIENTIST framed by a huge stack of condensors *(left)* and a stately insulator *(right)*, makes last-minute check on equipment comprising one of the world's largest power supply units. Installed in the tube-manufacturing facility of Sperry's Electronic Tube Division at Great Neck, N. Y., the unit is capable of delivering 100 million watts of peak power—enough to throw a searchlight beam well beyond the moon. The giant electrical output enables Sperry to test super-power klystron tubes it develops and manufactures for advanced radar and guided missile systems.

condensers, and conductors supply the high-voltage power needed to run the tests.

After the tests are complete, an extensive report is prepared on each tube's capability, giving the customer essential information before putting the tube into actual operation. EE

Scientists "Float on Air" To Investigate Space Problems

Scientists at Chance Vought Corp. are "floating on air" these days in the interest of space exploration, in an effort to solve some of the problems the space crewman will encounter when he hasn't the weight of a feather and when up feels the same as down.

The company's Astronautics Division has developed a pair of "airborne shoes" and a larger air-supported platform not unlike a floating chair. It is using them to study man's reactions to his own motions when he has no friction to keep him in place, and to develop tools and propulsion and stabilization devices needed in the environment of space.

Although the simple "air bearing" devices by no means duplicate the free-floating conditions of weightlessness, they do permit very free movement on a horizontal plane. Floating on a cushion of air fractions of an inch above a level surface, they demonstrate that the slightest push against a resisting object—or even an abrupt arm movement—is enough to put man in motion and alter his center of gravity.

"In space, Newton's third law—that for every action there is an equal and opposite reaction—will take on an entirely new significance," Dr. C. F. Gell, chief of life sciences for the Astronautics Division, points out.

"Without gravity or some means of stabilization, the space crewman, who pushes a lever in a space cabin, is likely to move more than the lever. Turning a bolt with a conventional wrench could rotate the crewman instead of the bolt. A welding torch, spray gun, or rivet gun could act like a small propulsion unit sending a crewman floating or tumbling away from the side of his space craft."

Vought Astronautics already has developed and platform-tested special anti-torque space tools which would not rotate the space crewman. One of the most interesting is called "plench," a combination plier and wrench.

The platforms also are providing data for development of small propulsion and stabilization devices for the individual. These could be used in or out of a space vehicle to anchor the crewman or take him where he wants to go.

Other platform projects include design of controls, lightweight seating, crew restraint, spaceship handholds, and other appointments. A new automatic controls evaluation simulator soon will go into service alongside the platforms for more intricate space development work.

A principal use of the air platform is for space orientation training and studies of man's center of gravity in various positions and attitudes. C. R. Adams, human factors engineer in Astronautics' life sciences section, has spent many hours on the platforms collecting such data, studying personal equipment needs and testing tool and fixture designs.

"Riding on the platforms gives the subject a very different involuntary reaction and muscle response—at least indicative of what he would experience in space," Mr. Adams said. "There is no question orientation and body control will be major problems at zero gravity, and there is no question the platforms can help prepare him for these."

The larger platform consists of a square base on which is mounted a space vehicle-type seat. Supporting the platform are three flat circular discs. Air is blown through the discs under a pressure of about 80 pounds per square inch to form a "bearing" between the discs and the flooring surface.

The air shoes are similar, except that each is little larger than a skate. Independent movement of the feet permits additional freedom and enhances the "space" effect. It also makes the skates very difficult to operate.

One slip, and the unskilled operator has a real appreciation of gravity. EE

C. A. Adams, human factors engineer in the life sciences section of Chance Vought's Astronautics Division, "floats on air" while testing special tools developed for use by the space man of the future. Here he uses a special antitorque "plench" — combination pliers and wrench —developed to prevent rotation of the crewman as he makes repairs to his vehicle in space. Mr. Adams is using a pair of "airborne shoes" to study man's reactions to his own motions when he has no friction to keep him in place.

Bureau of Standards System Divides Seconds into Millionths

The most highly accurate system devised by man for measuring time has joined the family of sundials, hour glasses, grandfather clocks, and wrist watches. The new system can break seconds down to parts in millionths and, at the same time, synchronize clocks to its ultraprecise standard.

The National Bureau of Standards has added the equipment to its already precise measurement facilities at Boulder, Colo. Before the new development, widely separated clocks could be synchronized only in thousandths of a second.

This significant advance in timing technique has been made possible by the Loran-C (LOng RAnge Navigation) system developed and produced by Sperry Gyroscope Company. Until now, Loran-C has been employed mainly to supply accurate navigation information to both ships and airplanes.

Although doubtful that a microsecond hand will replace a second hand on everyday watches, the Bureau believes the development holds great promise for both military and civilian projects.

The timing system, for instance, could greatly advance the techniques of weather forecasting by precisely measuring lightning flashes to determine the exact location of thunderstorms.

It also could be used to detect and pinpoint space vehicles and aircraft, as well as synchronize sensing devices monitoring all-important missile tests, and to survey offshore islands and remote areas with extreme exactness. Successful timing tests already have been run on the Atlantic Missile Range, Bureau scientists said.

The Bureau pointed out that a satellite traveling at an escape velocity of 25,000 feet per second could be miles away from its indicated position if separate tracking clocks disagree by only a fraction of a second.

Developed as a navigation system during World War II, Loran has emerged into the present-day Loran-C system. Facilities for its operation consist of a chain of

transmitters strategically located around the world to send highly accurate radio pulses to navigators using Loran-C equipment.

By measuring to fractional microseconds the length of time it takes various pulses to reach his receiver, the navigator is constantly informed on his exact position.

The National Bureau of Standards bought four Loran-C time receivers this year from Sperry to synchronize and set clocks in different locations to a relative accuracy better than 1 microsecond. EE

NSF, MSTS Sign Agreement On Antarctic Research Ship

The USNS *Eltanin*, an ice-strengthened cargo ship, will become a seagoing scientific laboratory of the U.S. Antarctic Research Program under the terms of an agreement announced recently by Dr. A. T. Waterman, director of the National Science Foundation (NSF) and Vice Admiral R. A. Gano, USN, commander, Military Sea Transportation Service (MSTS).

"Research projects aboard the *Eltanin* will encompass any scientific work that may be carried out on shipboard," Dr. Waterman noted. "The Foundation is now accepting proposals for research in the oceans adjacent to the Antarctic, and it is expected that the first research cruise will begin in the late fall of 1961."

The ship will be fitted to accommodate numerous disciplines, including meteorology, upper atmosphere studies, marine and terrestrial biology, physical oceanography, submarine geology, and geomagnetic studies.

The agreement between NSF, which administers the Antarctic Research Program, and MSTS, which owns and operates the *Eltanin*, provides for conversion of the cargo vessel into a polar research ship during the summer and fall. EE

Ionization Gauge Measures Atmospheres of Near Space

Intended to sniff the thin atmospheres of near space and to measure their density, several ionization gauges of a new design have been designed and built by the Westinghouse Electronic Tube Division for the National Aeronautics and Space Administration's Goddard Space Flight Center. Tested in space on November 15, 1960, as part of the instrumentation for an Aerobee Hi Rocket launched from Wallops Island, Va., one of these gauges provided direct measurements of pressures and densities prevailing at altitudes from 70 to 125 miles.

Because of their wide range of sensitivity—1 $\times$ 10^{-3} to 1 $\times$ 10^{-10} mm of mercury—the gauges are expected to be useful in gathering data at altitudes of from 70 to 450 miles, where prevailing molecular densities range from 5 $\times$ 10^{14} molecules per cubic inch to 5 $\times$ 7 molecules per cubic inch. Augmented by results of later probes, this data will be used to confirm and to extend data that has been accumulated previously through indirect measurement.

Until this experimental flight, efforts to adapt high-sensitivity ionization gauges to space investigation had met with little success because of problems of bulk and susceptibility to vibration. Although not literally "rugged" as the term is normally used, the new gauges have proved they can withstand acceleration and vibration adequately to function properly upon delivery to the altitudes to be investigated. Chief design steps providing this ability were development of tube elements of extremely low mass and new techniques for mounting these elements.

Designed as self-contained variants of the Bayard-Alpert ionization gauge, the gauges are triodes whose elements are a tungsten filament drawing 1.5 amperes at 4 volts, an ion collector working at —30 volts, and a grid working at +150 volts. These elements are mounted in a glass envelope 3½ inches long, 1 inch in diameter, into which the atmosphere can be admitted by "unstoppering" the open end of the envelope.

In use, electrons from the hot cathode are accelerated across the 150-volt potential difference between cathode and grid, acquiring sufficient energy to ionize gas molecules that have entered through the open port into the area of electron bombardment. (At the same time, to prevent spurious indications caused by the entry of ionized particles, a silvered ring-like ion trap just inside the port attracts these ions and neutralizes their charge.) Because of their positive charge, ions produced through electronic-molecular collision are propelled to the negatively charged ion collector and produce a direct current in the ion-collector circuit. Since the ratio of this current to the grid current is proportional to the number of electronic-molecular collisions, and to the number of gas molecules within the envelope at any moment, the ratio serves as a base quantity which is transmitted to earth to indicate the molecular density at that point in space. EE

IONIZATION GAUGE has been developed for direct measurement of density of atmospheres of near space.

KEEP your spine straight when lifting. Ray Hart, safety director for Dayco, uses unique dummy to prove the point.

Dummy Keeps Mum—But Gets Safety Theme Across

A dummy with a flat head, plywood "bones," and a trick spine is helping to prevent back injuries at all Dayco Corporation plants and warehouses. And even though he has a wooden head he's no dummy when it comes to getting his point across. Without a word he lets employees see for themselves that even heavy objects can be lifted without injury or strain.

Introduced at Dayco Corporation's Dayton Industrial Products Division in Melrose Park, Ill., the device is part of a long-range program to teach proper lifting techniques to employees in all divisions of the corporation.

The device works on a simple leverage principle. There are movable joints at the ankles, knees, hips, and shoulders. The backbone is a series of wooden blocks held together by elastic strips. The employee provides the lifting power by means of a handle at the base of the dummy's spine.

With the load properly placed, the dummy's knees are bent and the back is straight, almost vertical. When the employee applies pressure to lift the load, maximum strain is placed upon the dummy's legs instead of the back and he reaches a standing position without mishap. But when the load is too far forward, the dummy's back is forced to bend putting it under a strain. When the employee tries to make the dummy lift the load in this position the extra stress causes the backbone sections to separate.

"The result is a startling message which instantly gets through to everyone," said Ray Hart, safety director for Dayco. "We could talk all day about the right and the wrong way to lift and still not reach a lot of people. But 30 seconds with this little device and every man is thoroughly impressed. He may not remember an hour-long lecture on proper lifting techniques but he's not likely to forget this demonstration," he added.

Mr. Hart pointed out that approximately one fourth of all disabilities suffered by American workmen are caused by improper handling of materials. EE

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

AIRBORNE RADAR. By D. J. Povejsil and others. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J., 1961. 823 pages, 6¼ by 9¼ inches, bound. No price given. The eighth volume in the series, "Principles of Guided Missile Design," this book presumes considerable prior knowledge of the basic principles of electronics and electromagnetic propagation, of the weapons systems employing airborne radar, and of associated language. This particular volume is primarily concerned with airborne radar, but is applicable also to surface radar. It is the work of 25 contributors representing United States industry and government organizations in this field. It provides an understanding of basic radar technology and its relation to over-all weapons system design, with emphasis on the basic principles and systems analysis techniques, and how mathematical models may be developed to solve radar design problems.

ANALYTICAL TECHNIQUES FOR NONLINEAR CONTROL SYSTEMS. By J. C. West. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J., 1960. 223 pages, 5½ by 8¼ inches, bound. $5.75. Dr. West, of Queen's University of Belfast, writes primarily for control engineers requiring engineering analytical techniques for analysis of the performance of closed-loop automatic control systems, when amplitude nonlinear elements dominate the performance. He selects a few techniques which are of general application, and illustrates their principles by extending the implications of specific examples to general application. He discusses in this manner, the phase-plane method, harmonic analysis, the use of probability theory, and the equivalent gain technique.

APPLIED RADIATION AND RADIOISOTOPE TEST METHODS. Published as ASTM Special Technical Publication no. 268 by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., 1960. 112 pages, 6¼ by 9¼ inches, bound. $3.75. The 11 papers published in this volume examine the applications of methods involving radioisotopes to established industrial test methods, with the ultimate goal of adoption of these methods as routine test procedures. The test areas involved include diesel locomotive ring wear, grain boundary segregation, soil density and moisture content, hydrocarbon-sulfur analysis, magnesium oxide content in Portland cement, mixing uniformity, metal film thickness, permeability of organic sheet materials, and uniformity of coated fabrics.

THE AUTODYNE. By Otto Benedikt. Second edition. Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y., 1960. 193 pages, 6¼ by 9½ inches, bound. $10. This first English edition is a translation of the second edition of the author's description of the new type of rotary amplifier on which he began work in 1941 in Moscow. The German first edition (1957) was completed after his appointment to the Technical University of Budapest. The book treats only the most important basic problems, without dealing in detail with the computation methods and design particularities. References are made, however, to experimental autodynes, and to those already in use. In the introduction, Professor Tustin of the Imperial College (London) describes the machine as "a means to obtain control of any quantity that can be made to depend on a direct current, using the ordinary fixed frequency a-c power supply as the source of energy." The author expects that the new machine will be useful in many applications such as automatic control, electric welding, amplification, and d-c motor drives.

BALLISTIC MISSILE AND SPACE TECHNOLOGY, VOLUMES I, III and IV. Edited by D. P. LeGalley. Academic Press, Inc., 111 Fifth Ave., New York 3, N. Y., 1960. 3 volumes, 6¼ by 9¼ inches, bound. $9 each. The Fifth Symposium on Ballistic Missile and Space Technology, sponsored by the USAF, Space Technology Laboratories, and the Aerospace Corporation, brought together more than 1,000 United States scientists and engineers at the University of California in August 1960. Volume 2 of the Proceedings, "Propulsion and Auxiliary Systems," was reviewed in January 1961. Volume 1, "Bioastronautics and Electronics, and Invited Addresses," deals with the human element in space technology, inertial guidance and control, space communication, computers, computing and data reduction, and telemetry. The seven invited addresses are surveys of general aspects of the subject—international space competition, the challenge and future of man in space, United States achievements, and the management of space programs. Volume 3, "Guidance, Navigation, Tracking and Space Physics," covers those subjects, and includes papers also on space trajectories. Volume 4, "Re-entry and Vehicle Design," deals with the materials and engineering mechanics of re-entry, and discusses design from the standpoints of performance analysis, system description, and operational considerations.

ELECTRONIC ENGINEERING PRINCIPLES. By J. D. Ryder. Third edition. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1961. 428 pages, 6 by 9¼ inches, bound. $12.65. This third edition of a standard college text by the Dean of Engineering, Michigan State University, introduces solid-state principles and devices, while still maintaining the view of electronics as one science, employing two basic devices—the vacuum tube and the transistor—which achieve similar results. In keeping with this point of view, Dr. Ryder first examines similarities and differences in a joint study of the various phenomena, applications, and methods of analyses associated with the basic devices. Having thus laid a physical foundation for both vacuum and solid-state devices, he then discusses processes and circuits fundamental to Class A and B operation at nominal frequencies.

ELECTRONIC EQUIPMENT RELIABILITY. By G. W. A. Dummer and N. Griffin. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1960. 274 pages, 5½ by 8¼ inches, bound. $7.50. The authors present a conspectus of current knowledge on the subject of reliability in electronic equipment, a task suited to their affiliation with the Royal Radar Establishment. They first discuss the reliability problem in general, and then devote several chapters to failure rates, faults, and the effects of environmental conditions and constructional techniques in electronic equipment. Other chapters deal with circuit reliability and standard circuits, designing for maximum reliability, testing for, predicting, and calculating reliability, and the future outlook. A chapter on human engineering examines the problem of successful design of electronic equipment for human use. There is an extensive classified bibliography.

ELECTRONIC SURVEYING AND MAPPING. By Simo Laurila. The Ohio State University Press, 164 W. 19th St., Columbus 10, Ohio, 1960. 294 pages, 7 by 10 inches, bound. $6. The author has collected, listed, and analyzed available material on the application of electronics to surveying and mapping, and has mixed in his own experiences as researcher and teacher, first at the Finland Institute of Technology, and later at Ohio State University. He has arranged the book so that it will be usable by geologists unfamiliar with electronics, and by electrical engineers unfamiliar with geodesy. Part I presents the basic principles of electricity, electronics, electronic surveying and its instruments. In Part II the electronic and magnetic features of various electronic surveying systems are analyzed, emphasizing those functions which primarily affect the accuracy of measurements. In Part III, reductions and corrections of the instrument data are derived so that information obtained from the electronic surveying instruments may be applied to the ellipsoid or the map projection plane. Written as a college text, this book also will be valuable to all interested in this subject.

AN ENGINEERING APPROACH TO GYROSCOPIC INSTRUMENTS. By E. J. Siff and C. L. Emmerich. Robert Speller and Sons, Publishers, Inc., 33 W. 42nd St., New York 36, N. Y., 1960. 120 pages, 6¼ by 9¼ inches, bound. $7.50. The authors are intimately connected with their subject, as executives in research divisions of General Precision, Inc., and United Aircraft Corporation, respectively. They write for engineers, at a level intermediate between elementary explanations of gyroscopic effects, and complicated mathematical derivations. In the first chapter, they discuss the fundamental principles of gyroscopic motion, and the basic elements of primary applications, such as the gimballed gyroscope. The remaining three chapters examine applications, in three separate categories: basic gyro configurations such as displacement, rate, and integrating gyros; special gyro designs such as floated, air and fluid bearing, vibrating rate and particle gyros, with details on magnetic and electrostatic suspensions; and special instrument gyroscope applications—free, vertical, and directional gyros, and gyro platforms. "A comprehensive review of the principles and general features of existing instruments," according to Dr. C. S. Draper of Massachusetts Institute of Technology.

THE FERMI SURFACE. Edited by W. A. Harrison and M. W. Webb. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1960. 356 pages, 8¼ by 11¼ inches, bound. $10. This volume contains the 33 papers presented at a conference on the Fermi surfaces of metals, held in Cooperstown, N. Y., in August 1960, sponsored by the Air Force Office of Scientific Research and the General Electric Company. Of the eight sections into which the papers have been organized, several are topical, discussing the theory of the Fermi surface, the De Haas-Van Alphen effect, galvanomagnetic effects, cyclotron resonance, the anomalous skin effect, the magnetoacoustic effect, transport properties, and studies of alloys. The final section contains summaries of the theoretical and of the experimental considerations dealt with in the conference. Participating were representatives from the United States, Canada, Great Britain, Spain, France, and Japan, but there were no reports on Russian work in the field.

GRUNDZÜGE DER STRAHLENSCHUTZTECHNIK. By Thomas Jaeger. Springer-Verlag, Berlin, Germany, 1960. 392 pages, 6¾ by 10 inches, bound. DM 46.50. A treatise on the techniques of radiation shielding which "translates" the physicists' experience into a text for engineers. Major sections cover the principles of nuclear physics; biological aspects; radiation sources; theoretical and practical problems of radiation protection, falling into two major categories: the shielding of radiation from nuclear reactors, particle accelerators, etc., and the disposal of radioactive wastes. Extensive reference lists accompany the several chapters and the appendix includes source and subject indexes.

HYDRODYNAMICS. By Garrett Birkhoff. Second edition. Princeton University Press, Princeton, N. J., 1960. 184 pages, 6 by 9¼ inches, bound. $6.50. The over-all organization of this edition closely follows that of the 1950 edition. The material, carefully revised in detail and including new developments in the past decade, was presented in a graduate

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ENGINEERING Societies Library books, except bibliographies, handbooks, and other reference publications, may be borrowed by mail by AIEE members for a small handling charge. The Library also prepares bibliographies, maintains search and translation services, and can supply a photoprint or a microfilm copy of any item in its collection. Address inquiries to R. H. Phelps, Director, Engineering Societies Library, 29 W. 39 St., New York 18, N. Y.

course at Harvard University. Two special aspects of fluid dynamics are emphasized: the complicated logical relation between theory and experiment, and application of symmetry concepts. The relation between theory and practice, introduced in the first two chapters by cases wherein plausible reasoning had led to incorrect results, is closely studied in Chapter 3 in the special cases of flows with free boundaries, and further illuminated by an analysis and justification of modeling in Chapter 4. This chapter also introduces the second aspect dealt with, in describing the origins of modeling in symmetry concepts. Applications of these concepts are considered in the final two chapters, in solutions of problems involving compressible and viscous flows, and in developing the classical theory of virtual mass as a special case of the theory of homogeneous spaces.

HIGH FREQUENCY APPLICATIONS OF FERRITES. By J. Roberts. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J., 1960. 166 pages, 5 by 7½ inches, bound. $4.85. This brief monograph has been written for advanced students in electrical engineering and physics, and for those engaged in the design or operation of electronic equipment, by a member of the faculty of the University of London. The author deals first with the physical phenomena associated with ferrites to enable understanding of their properties. The remainder of the book deals with the use of ferrite components in communication and computer systems, with particular reference to principles of operation, and improved system performance arising out of their use. Included in the discussion are applications in inductor and transformer cores, switching cores, and microwave devices. Comparisons with alternative materials are made. The final two chapters discuss ferrites with rectangular hysteresis loops, and the special compound, barium ferrite, with its unique magnetic properties.

INTRODUCTION TO LAPLACE TRANSFORMS FOR RADIO AND ELECTRONIC ENGINEERS. By W. D. Day. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 1960. 183 pages, 5¾ by 8¾ inches, bound. $5.50. The author, who is with Northern Polytechnic (affiliated with the University of London), has prepared a text on the Laplace transformation for engineering students familiar with circuit principles, but whose knowledge of mathematics does not go beyond elementary differential equations and the properties of complex numbers. The method is approached via the solution of second-order equations rather than the Fourier integral and transform, and the treatment is not rigorous. The first five chapters serve to impart facility in the use of transforms, and are self-contained. The remaining chapters are less complete, designated by the author as introductions to more thorough treatments, dealing with the complex variable, the inversion and the product theorems, partial differential equations, and other transforms.

AN INTRODUCTION TO TRANSISTOR CIRCUITS. By E. H. Cooke-Yarborough. Second edition. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 1960. 158 pages, 5¾ by 9 inches, bound. $3.50. A good deal of material has been added in this second edition of a work which first appeared in 1957, based on a series of lectures delivered at University College, London. The material presented represents information acquired by the author and his colleagues during their work at the College, and the Atomic Energy Research Establishment, Harwell, and thus emphasizes the field of primary interest in those institutions—the nonlinear properties of transistors. Omitted are such subjects as transistor circuit noise, power and tuned amplifiers, and radio-receiver circuit design. Contents: transistor action, low frequency amplification, performance of transistor amplifier circuits, pulse circuits, circuit applications of transistors, application of transistors in automatic computers.

KEMPE'S ENGINEERS YEAR-BOOK FOR 1961, VOLUMES 1 AND 2. Edited by C. E. Prockter. 66th edition. Morgan Brothers (Publishers) Ltd., London, England, 1961. 2 volumes, 4¾ by 7 inches, bound. 87s 6d. This compendium of the modern practice of civil, mechanical, electrical, marine, gas, aeronautical, mining and metallurgical engineering contains revised information in almost every one of its 84 sections. It is a useful compilation, with an extensive index in Volume 2, although its wide coverage lessens its specificity, making it more useful in general reference than for the specialist. Although of British origin, its careful attention to other national standards and units makes it of universal application.

LECTURES ON COMMUNICATION SYSTEM THEORY. Edited by E. J. Baghdady. McGraw-Hill Book Company, Inc., 330 West 42nd St., New York 36, N. Y., 1961. 617 pages, 6¼ by 9¼ inches, bound. $12.50. This volume contains, in rewritten and amplified form, 23 lectures prepared and delivered by 18 members of the faculty of the Massachusetts Institute of Technology to a summer course attended by practicing communication engineers. The topics covered are: the mathematical representation of signals and disturbances, characterization of transmission channels in terms of observed behavior at the transmitting and receiving terminals, discussion of various corrective measures and signal design and processing techniques aimed at combatting the multiplicative and additive disturbances introduced in the transmission channel, and application of the background material to the synthesis of communication systems. Unique features of the book are inclusion of unpublished material developed for this publication, and indication of many important unsolved research problems.

LINEAR GRAPHS AND ELECTRICAL NETWORKS. By Sundaram Seshu and Myril B. Reed. Addison-Wesley Publishing Company, Inc., Reading, Mass., 1961. 315 pages, 6 by 9¼ inches, bound. $9.75. The authors have developed their material from lectures they have given in graduate courses in various United States universities. Prior knowledge of matrix and Boolean algebra, Laplace transformation, and theory of functions is assumed, but the special concepts of linear algebra, upon which the theory of graphs depends, are explained. To establish the foundations of network theory, the authors determine the mathematical properties of the Kirchhoff equations by means of the linear graph, as it determines the coefficient matrices of these equations. The first five chapters contain the basic theory of graphs, and the last five (two thirds of the book) discuss various applications, such as in network analysis and synthesis, the theory of switching, topological formulas, communications networks, and flow graphs.

NATIONAL ELECTRONICS CONFERENCE: PROCEEDINGS. VOLUME XVI. Published by the National Electronics Conference, Inc., 228 N. La Salle St., Chicago 1, Ill., 1960. 885 pages, 8¾ by 11¼ inches, bound. No price given. All those concerned with electronics research, development, and application will welcome this 16th annual compilation of papers presented at the 1960 NEC; librarians may not welcome its physical measurements—double the height and width of the previous 15 volumes to accommodate the great increase in material. The papers were available at the Conference for the first time in 1960; and the emphasis is on digital data transmission and solid-state devices. In addition to the topics mentioned above, the following areas are discussed in groups of full-length papers: feedback control systems, antennas, microelectronics, circuit theory and applications, including transistor and amplifier circuits, magnetohydrodynamics, active networks, parametric devices and techniques, space science, engineering management, instrumentation, ultrahigh frequency, and ultrasonic engineering. Abstracts of papers concerned with combinational logic, symbols and notations, sequential logic and logical design also are included.

RELATIVISTIC ELECTRON THEORY. By M. E. Rose. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1961. 302 pages, 6 by 9¼ inches, bound. $9.50. The author, who is chief physicist at the Oak Ridge National Laboratory, assumes knowledge of the general principles and methods of quantum mechanics on the part of his readers. The book is intended as a comprehensive treatment of the single particle description of relativistic quantum mechanics. The chapter headings indicate the scope of the book: nonrelativistic spin theory, relativistic quantum mechanics of free particles, Dirac plane waves, particle in electromagnetic fields, Dirac particle in a central field, approximate methods, neutrino theory.

SEMICONDUCTOR ABSTRACTS, VOLUME VI, 1958. Edited by J. J. Bulloff and C. S. Peet. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1961. 528 pages, 8½ by 11¼ inches, bound. $14. This annual compilation of abstracts of literature on semiconducting and luminescent materials and their applications is a co-operative effort of the Battelle Memorial Institute, the Electrochemical Society, and the Air Force Office of Scientific Research. It covers material published up to the end of 1958, including some references to much earlier publications not previously abstracted. The subject index is more complete than in preceding volumes.

SPACEFLIGHT TECHNOLOGY. (PROCEEDINGS OF THE FIRST COMMONWEALTH SPACEFLIGHT SYMPOSIUM, 1959) Edited by K. W. Gatland. Academic Press, 111 Fifth Ave., New York 1, N. Y., 1960. 365 pages, 6 by 9¼ inches, bound. $11. Many of the 18 papers in this volume represent the first published results of original research; together, the papers are intended to foreshadow and encourage a technological program of aerospace development among British Commonwealth countries. The papers have been arranged into nine topical sections. The first section discusses Commonwealth activities in interplanetary exploration, with two papers concentrating on University participation and Canadian facilities. Section two deals with launching of space vehicles, discussing solid propellant rockets, nuclear thermal fission rockets, the Woomers tracking and launching station, and a spaceflight program based on Blue Streak. The three papers of section four are concerned with aerospace vehicles and reentry, and the remaining five sections deal with propulsion systems; cabin-conditioning equipment for manned satellites; instrumentation of unmanned satellites; tracking, communication (Jodrell Bank), and navigation; and minimum propulsion for soft moon landing of instruments.

TRANSISTOR CIRCUIT ANALYSIS. By M. V. Joyce and K. K. Clarke. Addison-Wesley Publishing Co., Inc., Reading, Mass., 1961. 461 pages, 6¼ by 9¼ inches, bound. $10.75. Presenting the basic methods of analysis involved in the design and understanding of junction transistor circuitry, this book is not a guide to existing transistor circuits. The transistor models employed in the analysis are selected, and restricted to a small number that are all easily interrelated. The simple low-frequency models are presented first, and are related to the underlying physical processes that occur in the device; complications, such as high-frequency effects, noise, and saturation effects are introduced after these basic concepts are clear. The first chapter outlines the fundamentals of physics necessary for understanding the dependance of the various model parameters on temperature, operating conditions, and transistor construction material.

TRANSDUKTORTECHNIK. By Walter Schilling. Verlag von R. Oldenbourg, Munich, Germany, 1960. 267 pages, 6½ by 9½ inches, bound. DM 40. This book deals with magnetic amplifiers, single and 3-phase, energized from a 50-cycles-per-second source. The development begins with a linear inductance, then introduces a ferromagnetic core, and systematically more complex forms of magnetic amplifiers are built up. After the discussion of the steady-state performance, the dynamics of magnetic amplifiers are introduced and many applications are described. This is followed by an example for the calculation of a magnetic amplifier. Definitions of (German) terms and a very small bibliography (only 17 entries) conclude the contents. Both theoretical and practical data are presented. The illustrations of the book are excellent. The most outstanding feature of the book is the profusion of well-planned and masterly executed cathode-ray oscillograms. This book is likely to be appreciated most by engineers who already have background in the field of magnetic amplifiers.

V.H.F. LINE TECHNIQUES. By C. S. Gledhill. Edward Arnold (Publishers) Ltd., London, England, 1960. 60 pages, 5½ by 8¾ inches, bound. 12s 6d. Affiliated with the University of Manchester, the author writes primarily for the undergraduate student, discussing some methods of using transmission lines as elements to perform various functions of communication circuits. The circle-diagram technique for the solution of transmission problems is stressed: rigorous analysis of the method discussed is given where applicable, but in every case it is shown that the circle-diagram method yields the same results more rapidly. The first chapter is devoted to the Smith Chart for transmission line calculations, and methods for its use. The next three chapters discuss single-frequency matching techniques, broadband matching techniques, and transmission-line transformers. Additional techniques and methods of line measurements are covered in the final chapter and an appendix.

X-RAY METALLOGRAPHY. By A. Taylor. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1961. 993 pages, 6 by 9¼ inches, bound. $27. As in his "Introduction to X-Ray Metallography," (Chapman & Hall, 1945), the author provides here a book which is both a work of reference and a guide to the literature, requiring no prior knowledge of the subject. In all other respects, however, he has written a completely new book. Its main theme is the application of X-ray techniques to the study of metals and their alloys, but analogous neutron and electron diffraction procedures also are described. Basic theory, specific applications, and experimental procedures are described in detail, along with such topics as the production of X-rays, X-ray absorption, and X-ray and neutron radiography.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

BIOLOGICAL EFFECTS OF MICROWAVE RADIATION, *Volume II*. The proceedings of the Fourth Annual Tri-Service Microwave Conference have been published under the above title. The emphasis at the Rome Air Development Center, which sponsored this conference, has been to obtain better understanding of biological effects observed over a 6-year period. The papers in this volume range from discussions of fundamental considerations of the molecular responses of living tissues to microwave, to the organizational and administrative problems of establishing programs of protection. The book was edited by Mary Fouse Peyton, of the New York University Post-Graduate Medical School, and is available from Plenum Press, Inc., 227 W. 17th St., New York 11, N. Y., for $10.

FEDERAL AGENCIES FINANCING RESEARCH. This 26-page report on agencies, scientific fields, and suitable contract forms is designed to help persons or companies hoping to work on government research programs. The booklet gives information on the programs, procedures and organization of each United States agency which awards research contracts, and the officers to approach for further specifics. Copies may be obtained from the Social Legislation Information Service, Inc., DuPont Circle Building, Washington 6, D. C., for $1 each.

ADVANCES IN X-RAY ANALYSIS, *Volume 4*. This addition to the series discusses recent developments in the field of X-ray analysis; it contains the complete texts of 38 reports presented at the Ninth Annual Conference on Applications of X-ray Analysis held last August. Volumes 1-3 of the series contain the proceedings of the 1957, 1958, and 1959 conferences. The papers in Volume 4 discuss theory and new instrumentation, applications of the method, crystal structure, electron probe research, and a number of other subjects in this field. The book is available from Plenum Press, Inc., 227 W. 17th St., New York 11, N. Y., for $15.

RECOMMENDED GRAPHICAL SYMBOLS. *International Electrotechnical Commission Publication 117-2* specifies the 78 recommended graphical symbols for machine, transformers, primary cells, and accumulators (batteries). Publication 117 will include symbols for all branches of electrical technology, but in order not to delay availability of sections it is being issued in parts as they are approved. The 30-page publication may be obtained for $2.40 from the American Standards Association, 10 E. 40th St., Dept. P 209, New York 16, N. Y.

TUNNEL DIODE MANUAL. The General Electric Company has published this 96-page book on the use of tunnel diodes in electronic circuits. The new application manual is intended as a reference source for circuit design engineers in the new application technology of tunnel diodes. It gives information on amplifiers, oscillators, switches, logic circuits, ratings and characteristics, and test circuits. Copies are available at $1 each from the General Electric Co., Kelley Building, Liverpool, N. Y.

DATA PROCESSING ANNUAL *Reference Guide, Volume 2*. This is a 260-page cloth-bound book designed for users of punched card, punched tape equipment, and business computers. The "Computer Guide" feature introduced in Volume 1 has been updated by displaying all commonly used types of current electronic computers, with basic descriptions and characteristics. A Computer Comparison Chart gives the specifications of each type. A Bibliographical Index gives information on articles which have appeared in periodicals, indexed by subject and author. A section is included on wiring techniques for punched card equipment. The price is $15 from Gille Associates, Inc., 22nd Floor Book Tower, Detroit 26, Mich.

DEVELOPMENT OF HIGH-TEMPERATURE STRAIN GAGES. *National Bureau of Standards Monograph 26* summarizes work done in a research program for developing new types of strain gages for high-temperature use. Sponsored by the Navy and Air Force, the program has included an investigation of the properties of high-temperature strain gage materials, the development of high-temperature strain gages, and the development and evaluation of cements for these gages. The monograph is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 20¢.

THE INTERNATIONAL TRANSISTOR SUBSTITUTION GUIDEBOOK. This guidebook was written by K. A. Pullen, senior project engineer of the Aberdeen proving grounds in Scotland. It represents a painstaking effort to serve the electronic industry with accurate transistor substitution information. The selections listed are based on a critical and detailed examination of the electrical characteristics of both the original transistor and the suggested substitute, and on a comparison of the physical specifications of transistors manufactured in the United States and six foreign countries. The guidebook is priced at $1.50 from John F. Rider Publisher, Inc., 116 W. 14th St., New York, N. Y.

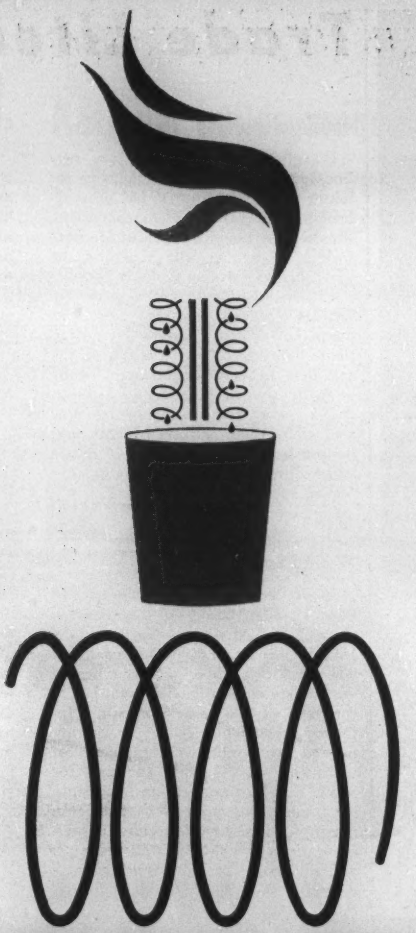
A NEW LOOK AT ENGINEER ATTITUDES. This 60-page report uses depth interviews and qualitative questionnaires from 131 engineers in various fields and companies to evaluate engineers' attitudes toward their jobs, management, salaries, and other aspects of their lives which are related to their jobs. Direct quotes from individual respondents are given, including suggestions for improving the lot of engineers in general. This study by Deutsch and Shea also draws on other recent studies for comparison. Copies of the report are available from Industrial Relations News, 230 W. 41st St., New York 36, N. Y., for $3.50.

BASIC TRANSISTORS. This illustrated textbook by Dr. Alexander Schure presents a comprehensive basic coverage of the transistor. The book opens with a discussion of atoms and semiconductors, and then analyzes the basic p-n junction diode. Basic transistor circuits are examined and their action completely described and analyzed. Coverage includes transistor biasing, transistor characteristics, conventional and power transistors, amplifiers and oscillators, and tetrode units. Review questions are included at the end of each section. Priced at $3.95 (soft cover) or $5.95 (bound), the book is available from John F. Rider Publisher, Inc., 116 W. 14th St., New York 11, N. Y.

SEMICONDUCTOR TECHNOLOGY. Edited by G. K. T. Conn, this is a transcript of a series of articles which were formerly published in *Research*. The 12 articles are intended to present a survey of typical topics in the semiconductor field. There are several articles on the preparation of pure materials and on controlled alloying, and attention is given to transistors and the problems of handling power; the parameters which determine optical behavior; the design, manufacture, and testing of infrared photocells; organic semiconductors; solid-state devices; and the characteristics and applications of bismuth telluride. The United States distributor is Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., and the price is $2.25.

OTS REPORTS. The following publications have been made available to the public by the Office of Technical Services. *Organic Semiconductor Study*, by J. B. Rust and others, presents the results of experiments for the temperature dependence of the resistivity for 13 organic compounds. No. PB 171 177, $1.75. *Investigation of Organic Semiconductors*, by G. P. Brown and S. Afterbut, relates experiments determining specific resistivity as a function of temperature for various organic compounds. No. PB 171 340, $2.25. *Power Requirements for Space Communications* compares the ideal space communication system with various types now used, and discusses the factors affecting the choice of such a communications system. No. SCTM 179-6 (51), 75¢ *Chinese Mainland Science and Technology*. This bibliography lists 380 research reports and translations of foreign technical literature on Communist Chinese science and technology. The listing covers the period from 1946 to late 1960. No. SB-442, 10¢. *Atlas of the Far Side of the Moon*, by N. P. Barabashov, A. A. Mikhaylov, and Yu N. Lipsky, of the Russian Academy of Sciences, has been translated into English. The Atlas contains 30 of the photographs transmitted by the Soviet rocket which orbited the moon in 1959, a detailed description of how the pictures were taken, four maps of the moon's far side prepared by Russian astronomers, and a 110-page "catalogue of formations," to accompany the photographs. No. 61-21955, $3. All publications listed above may be ordered from the OTS, U. S. Department of Commerce, Washington 25, D. C.

1960 SUPPLEMENTS TO THE BOOK OF ASTM STANDARDS, ten parts. These supplements give in their latest form standard specifications, tests, definitions, and recommended practices which are being issued for the first time or have been revised since the 1958 *Book of Standards*. *Part 1, Ferrous Metals Specifications*, includes 63 standards on such products as steel pipe, tubes, castings, and heat-resisting steels. *Part 2, Non-Ferrous Metals Specifications and Electronic Materials*, gives 57 standards for copper and copper-base alloys, zirconium, lithium, and materials for electron tubes and semiconductor devices, among others. *Part 3, Methods of Testing Metals (Except Chemical Analysis)*, includes 19 standards for tests for mechanical properties, effect of temperature, dosimetry, electrical and magnetic properties, nondestructive testings, metallographic tests, and tests for metal powders. *Part 7, Petroleum Products, Lubricants, Tank Measurement, Engine Tests*, contains 41 standards for crude petroleum, motor and aviation fuels, industrial oils, electrical insulating oils and others. *Part 9, Plastics, Electrical Insulation, Rubber, Carbon Black*, includes 68 standards for tests for mechanical, thermal, optical and permanence properties of plastics, electrical insulating materials, automotive and aeronautical products, and related materials. The other parts give standards for such materials as cement, masonry, wood, and textiles. Priced at $4 per part or $40 per set, the supplements are available from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.



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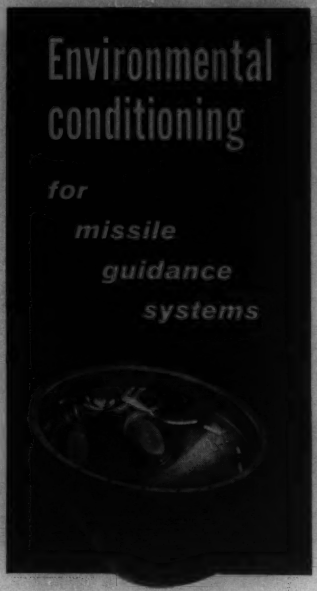

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Trade Literature . . .

Industrial Lighting . . .

"Lighting for Industry," a new booklet (No. B-570) on lighting for better seeing in industry, has been released. Addressed to plant executives, the 16-page booklet explains in nontechnical language what's behind the new higher lighting levels recommended for industry. Included are the new recommended footcandle levels; a discussion of the quality factors in plant lighting; an explanation of the specific benefits which can result in the properly lighted plant; and 10 illustrated "case histories" showing how and where these lighting benefits paid off for the users. *Better Light Better Sight Bureau of New York City, 750 Third Ave., New York 17, N. Y.*

Plasma Spray . . .

New development in the process of plasma spray coating for space materials and critical defense parts are described in bulletin 6114. The company has developed three major types of plasma spray equipment essential to complete plasma spray processing. Included are capabilities for the coating of re-entry bodies, development of thermal-erosion barrier coatings for rocket engine applications, coatings for nuclear applications, self-supporting or free-standing shapes as well as various corrosion, wear-resistant, and dielectric coatings. *Systems Management Div., Western Gear Corp., P.O.B. 182, Lynwood, Calif.*

Impedance Measuring System . . .

ESI Catalog Sheet C-13, 4 pages, describes the new model *291-A* Universal Impedance Measuring System for high-accuracy measurements of resistance, conductance, inductance, and capacitance and the dissipation factor (D) and storage factor (Q) for capacitors and inductors. Detailed specifications and circuit diagrams are given for the *290-A* impedance bridge, *840* d-c generator-detector, and *860* a-c generator-detector which comprise the matched system. Application drawings illustrate 3- and 4-terminal measurements, resistance limits checking, inductance and capacitance measurements, voltage divider checking, and substitution measurements from 10 parts per million. *Electro Scientific Industries, 7524 S. W. Macadam Ave., Portland 19, Ore.*

Corrosion Resistance . . .

A 24-page illustrated brochure analyzes the seven basic types of corrosion and shows what specific kinds of metals best resist them. These include brass, naval bronze, silicon bronze, nickel and high-nickel alloys, stainless steels, aluminum, copper, monel metals and high-temperature alloys. A corrosion guide chart lists 136 types of corrosive agents and shows how well each of eight types of metals resist each of these agents. *The H. M. Harper Co., Morton Grove, Ill.*

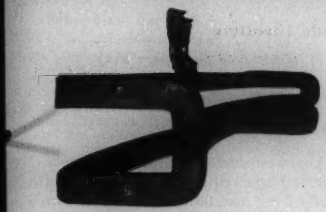
G-15 Program Reports . . .

Reports describing two electricity distribution programs for the Bendix *G-15* electronic digital computer are now available. One report, "Distribution Primary Radial Circuit Calculations," describes the program for the rapid solution of electric distribution radial circuit voltage drop, loss, and fault current calculations. The second report, "Power Network Load Flow," describes the *G-15* program designed to solve for flows and voltages at all busses and lines in an electric network. *Bendix Computer Div., 5630 Arbor Vitae, Los Angeles 45, Calif.*

Electronic Control Meters . . .

According to the fact file, the company's electronic control meters are completely self-contained instruments with one or two adjustable control arms that perform the dual functions of indication and control. Operating entirely without electrical contacts at the set points, they are said to provide the multiple advantages of continuous output signal past control setting with accurate, uninterrupted full-scale indication and automatic resetting. Data is provided to support the claim that the contactless electronic control meter is a foolproof, fail-safe control and indication mechanism, ideally adapted to current concepts of miniaturization and the employment of modular apparatus, that provides accurate monitoring and control whenever an electrical signal is available. Requests for the Electronic Control Meter Engineering Fact File should be directed to *Sales Dept., International Instruments, Inc., 88 Marsh Hill Rd., Orange, Conn.*

(Continued on page 32A)



Upper and lower coils before installation.

National builds unique magnet coils for 3-billion electron volt accelerator

Coils assembled in magnet frame of accelerator. Note connections for cooling fluid which is circulated through hollow conductors.

For the new Princeton-Pennsylvania Accelerator, National manufactured, inspected, tested and delivered 40 finished magnet coils.

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Extremely complicated coil configuration. Each coil was 12 ft. long, 2 ft. wide, and weighed 800 lb. Each coil was wound in eight individual layers, consisting of four turns of ½" square hollow copper conductor. No conductor splices were permitted internally in the coil. Each layer was wound with continuous conductor lengths of 92 ft. to 124 ft.

Rigid monolithic insulation system—required by the high pulse rate producing fatiguing mechanical forces. Turn-to-turn bonding strength is greater than 500 psi, and shear strength greater than 1000 psi.

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Trade Literature

(Continued from page 30A)

"Grounding Facts" . . .

Latest information on National Electric Code requirements most likely to affect the installation and operation of portable electric tools and equipment is available in the revised edition of "Grounding Facts," an 8-page illustrated booklet. Designed to benefit those who specify, install, use, and inspect electrical appliances and equipment, the booklet interprets and clarifies revised code requirements and provides up-to-date information on new types of grounding devices developed especially to satisfy the new requirements for safety. *The Arrow-Hart & Hegeman Electric Co., 103 Hawthorn St., Hartford 6, Conn.*

Zener Diode Bulletin . . .

A 4-page bulletin covers zener diode theory, characteristics and applications. Typical circuits using zener diodes are shown for: the shunt regulation of both a-c and d-c voltages, the voltage reference element in a transistor-controlled regulated power supply, the cathode resistor in vacuum tube amplifiers, the regulation of vacuum tube heaters, and the suppressed zero voltmeter with expanded scale. Advice on the use of zener diodes in series, as well as in parallel, is included. *CBS Electronics, Engineering Information Services, 100 Endicott St., Danvers, Mass.*

Flexible Laminates . . .

An 8-page brochure describes "Irvington" brand flexible laminates for temperature classes A and B. Listed are standard combinations and typical properties of varnished cambric and polyester film laminations with other materials, including fish, rag, kraft and asbestos papers, and glass fabrics. A description of applications for each combination of insulating materials is included, along with a detailed discussion of the common laminating materials offered in duplex and triplex constructions. This variety of laminated combinations permits control and selection of electrical, thermal, and mechanical properties for precise specifications. A new polyester laminate employing a unique triplex construction to achieve a web/film/web lamination without an adhesive or other bonding agent is also described. *Irvington Div., Minnesota Mining and Manufacturing Co., 900 Bush Ave., St. Paul 6, Minn.*

(Continued on page 36A)

Personnel Service

(Continued from page 34A)

with outside suppliers to provide those parts of system needed to complete the job. Salary, $9-$15,000. (c) Senior or Junior Electrical Engineer, graduate, to work under the direction of a project engineer to produce prototypes of complete systems requirements in the field measurement and control systems in industrial and military type jobs. Salary, $6250-$12,000. Location, New Jersey Metropolitan area. W284.

CONTRACT SALES REPRESENTATIVE, with at least five years' experience, to make field contacts. Should have the stature to ultimately take charge of Military Contract Sales Division. Prior experience in electronics, optical or scientific instrument field required. Salary open. Location, New York Metropolitan area. W280.

INSTRUMENTATION ENGINEER, graduate electrical, with five to ten years' experience, for the development and application of instruments and automatic controls in the electronic, electrical end as applied to petroleum processes. Salary open. Location, New York City. W279.

ELECTRICAL ENGINEER, graduate, with three to five years' experience in overhead distribution engineering in public utility; must have a working knowledge of modern residential underground distribution together with a working knowledge of easements and right-of-ways. Work will include design of new distribution lines, locating services, relocating lines and cost estimating. Must be able to calculate short circuit current, pole loading, capacitor requirements, entrance requirements. Both field and office experience desired. Location, West. W270.

ENGINEER, mechanical, electrical, or civil, part-time 20 hours per week or full-time to abstract articles from engineering publications. Retired engineer will be acceptable particularly those who have written papers for publication and have knowledge of some foreign language. Salary open. Location, New York City. W262.

ENGINEERS, graduate electrical or mechanical, preferably at the Master's level, with experience in the areas of circuit design and servo mechanisms. Small company. Salary open. Location, Massachusetts. W259.

PROJECT ENGINEER, 25-35, graduate electrical, with a minimum of three years' experience with the development, testing and manufacture of series wound motors. Must have product development interest in insulating, winding and connecting problems, and recommend designs consistent with U.S. and foreign regulatory agency specification. Salary open. Location, Connecticut. W254(a).

PRODUCTION ENGINEER, electrical graduate, with one to two years' experience in power cable or allied fields. Salary, $7200. Location, New Jersey Metropolitan area. W247.

TEACHING PERSONNEL. (a) Associate Professional, Director of Engineering Technology, Master of Science degree with Bachelor of Science degree in engineering, with teaching experience in engineering technology. Some industrial and administrative experience necessary. Duties will include administration and teaching electronics, basic electrical circuits and machinery. Salary, $7500-$9000 for a ten month year, depending upon qualifications. (b) Associate Professor of Physics. Doctor's degree required, with teaching experience, to teach engineering physics. Teaching experience on college level preferably in engineering school. Salary, $7500-$9000 for a nine-month year. (c) Assistant or Associate Professor, of electrical engineering. M.S. in electrical engineering, to teach courses in electric circuits, network analysis and field theory. Teaching experience on college level. Rank and salary depending upon qualifications. Location, South. W240.

ELECTRICAL ENGINEER, graduate, with three to five years' experience in industry with at least one-half of experience in plant engineering work. Will supervise equipment installations and electrical maintenance required. Salary, $7560-$8520. Location, Pennsylvania. W228(a).

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Automation and Remote Control

Avtomatika i Telemekhanika)—Articles on all phases of automatic control theories and techniques. Published monthly by the Academy of Sciences, U.S.S.R. *('57, '58, '59 and '60 issues available)*

Measurement Techniques

(Izmeritel'naia Tekhnika)—Published monthly by Academy of Sciences, U.S.S.R. Particularly interesting to those engaged in study and application of fundamental measurement. *('58, '59 and '60 issues available)*

Instruments and Experimental Techniques

(Pribory i Tekhnika Eksperimenta)—Bi-monthly published by the Academy of Sciences, U.S.S.R. Articles relate to function, construction, application and operation of instruments in various fields of experimentation. *('58, '59 and '60 issues available)*

Industrial Laboratory

(Zavodskaya Laboratoriya)—Published monthly by the State Scientific-Technical Committee of the Council of Ministers, U.S.S.R. Presents articles on instrumentation for analytical chemistry and physical and mechanical methods of material research and testing. *('58, '59 and '60 issues available)*

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which contains complete information about the ISA *Soviet Instrumentation and Control Translation Series.*

NAME.....
COMPANY.....TITLE.....
ADDRESS.....
CITY.....STATE.....

Trade Literature
(Contiued from page 38A)

"Semiconductor Selector Guide" . . .

A new 16-page brochure includes technical data on 43 devices for military applications and lists the mechanical construction and electrical ratings of every transistor, diode, rectifier, and microwave diode in the company's *500*-type semiconductor line. The military units consist of germanium alloy and mesa transistors, microwave diodes, and point contact, gold bonded, silicon bonded and silicon junction diodes which meet the specifications of MIL-E-1, MIL-S-19500, MIL-T-19500, and other USAF, USN, and JAN ratings. Detailed information on epitaxial silicon and germanium transistors and epitaxial varactor diodes is included in the brochure. *Sylvania Electric Products Inc., 1100 Main St., Buffalo 9, N. Y.*

Motor Couplings . . .

This 6-page folder entitled "Type *MC* Geared Flexible Motor Couplings," brings together all the pertinent data on the company's motor couplings. It includes the three new features added to the line: a new corrosive duty cover that has exceptional resistance to acids, alkalines, and solvents for applications that subject couplings to chemical attack; a new spacer adapter that speeds and eases maintenance of coupling, driven pumps, and compressors by permitting installation with an access gap between shaft ends; and a larger size added to the line that now extends the application range of the couplings to a 2⅜-inch-bore size. Copies of Folder 2975 are available from *Link-Belt Company, Dept. PR, Prudential Plaza, Chicago 1, Ill.*

Glass-Encased D-C Capacitors . . .

A 4-page catalog on type *GA* glass-enclosed high-voltage d-c capacitors describes how these capacitors may be used for applications requiring compact, lightweight units for continuous use at 85 C for 10,000 hours. They are designed to operate over the wide range of —60 to 125 C. Triple dielectric constructoin enables the capacitor to withstand the highest voltage stresses with the greatest safety factor. Photographs, drawings, and specifications supplement the text. Write for Catalog No. 102 to *Corson Electric Mfg., Corp., 540 39th St., Union City, N. J.*

(Continued on page 38A)

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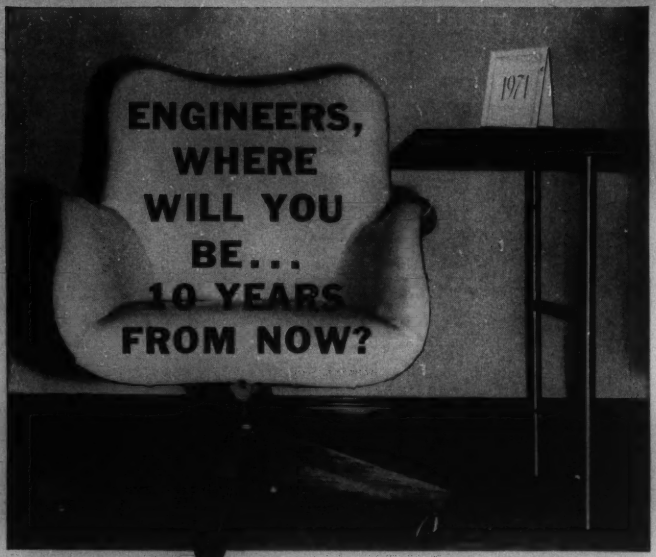

Perhaps you've been doing as well as you'd expected—*up to now*. But, if you're apprehensive about the future—if you've wished your assignments were more stimulating—your work more rewarding—you owe it to yourself to investigate the opportunities at Motorola.

Here you will be encouraged to use *all* of your creative talents. You'll work on projects that spark vision, that inspire imagination. Because Motorola is an "engineer's company" you'll be working with respected men who can contribute to your growth—men who are quick to recognize and advance skill. You'll be working for a *secure*, diversified company not wholly dependent on one single market.

There are dozens of fine opportunities covering a wide range of fields of interest—just a few of which are listed below.

Write today. We'll send you a complete description of "Your Life at Motorola"—in Chicago; Phoenix; Riverside, California; Culver City, California; Minneapolis, Minnesota. Naturally your request will be kept in complete confidence.

- Radar transmitters and receivers
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- Electronic countermeasure systems
- Military communications equipment design
- Pulse circuit design
- IF strip design
- Device using kylstrom, traveling wave tube and backward wave oscillator
- Display and storage devices

2-WAY RADIO COMMUNICATIONS
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- Transmitter design and development
- Power supply
- Systems engineering
- Antenna design
- Selective signaling
- Transistor applications
- Crystal engineering
- Sales engineering
- Design of VHF & UHF FM communications in portable or subminiature development
- Microwave field engineers
- Transistor switching circuit design
- Logic circuit design
- T.V. circuit design engineering
- Home radio design
- New product design
- Auto radio design
- Mechanical engineering
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All qualified applicants will receive consideration for employment without regard for race, creed, color, or national origin.

MOTOROLA inc.

Trade Literature

(Continued from page 36A)

Emergency Generators . . .

"Factors To Be Considered When Installing Emergency Generators" is the title of a 4-page folder, a reprint of an article on the subject of emergency generating equipment. The bulletin covers planning and engineering prior to the installation of the unit. Intended as a guide to point out some of the more common problems that may arise in standby installations, the article stresses the necessity for complete reliability in an engine-generator set. *ONAN Division of Studebaker-Packard Corp., 2515 University Ave. S.E., Minneapolis 14, Minn.*

Ignitron Excitation Circuits . . .

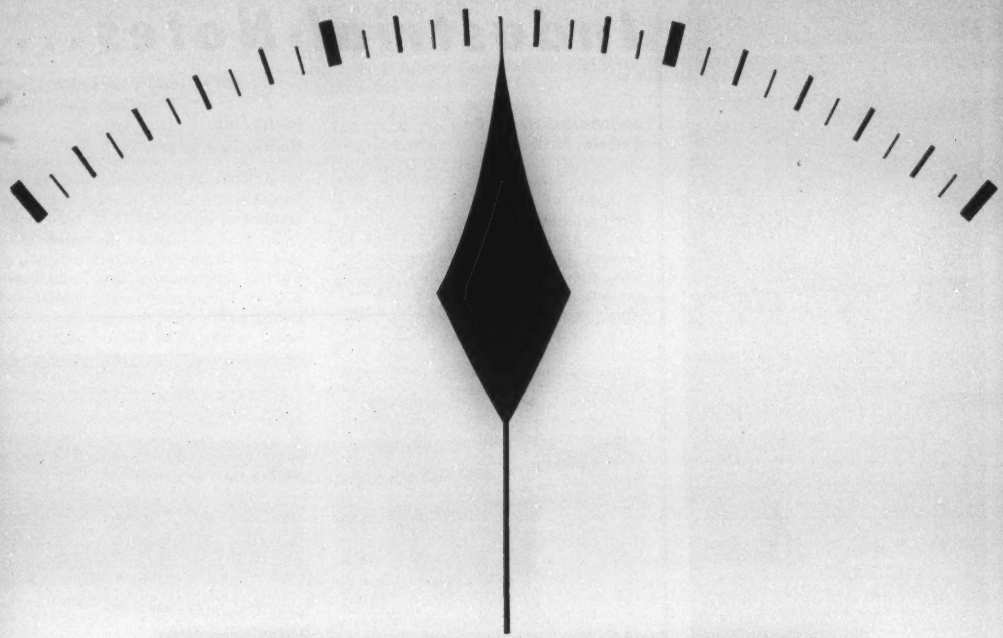
Bulletin PT-50, 16 pages, contains detailed information, of particular interest to designers of equipment for military application, on ignitron excitation circuits. The bulletin explains the functions of the associated electrodes (anode, grid and ignitor). It also details typical circuits which assure accurate and reliable firing, and contains schematics, graphs, and charts to illustrate the technical data. *General Electric Power Tube Dept., Schenectady 5, N. Y.*

Computa-Guide . . .

The "Computa-Guide" is a graphic aid for quickly determining the performance of r-f doublers and triplers, as well as straight-through amplifier electron tubes. The "Computa-Guide" saves engineers work by eliminating much of the mathematics involved in calculating the harmonic components of a complex wave form. For convenience, all formulas needed to derive final tube performance are included. *Amperex Electronic Corp., Advertising Dept., 230 Duffy Ave., Hicksville, N. Y.*

"Beckman Bits" Quarterly . . .

This first edition of the new quarterly contains 14 pages of articles, illustrations, and application information about data-processing equipment, amplifiers, and systems management personnel and techniques. Among the features is a documented report on exhaustive test results on the model *210* data-processing system. Copies of "Beckman Bits" are available from *Beckman Systems Technical Publications Dept., 325 Muller St., Anaheim, Calif.*



New Westinghouse Economy Switchboard Instruments —accuracy permanently assured by Taut Band Suspension

This new K-221 Westinghouse 4½" rectangular 100° scale design offers the greatest economy of any high quality switchboard instrument available on the market today!

Yet these a-c and d-c instruments give you the superior performance of Westinghouse Taut Band Suspension. No friction; almost infallible repeatability; higher sensitivity, less upkeep, and greater durability than pivot-jewel bearing types. And Westinghouse *tbs** instruments will withstand extreme vibration and shock that would play havoc with ordinary designs.

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For complete details on K-221 switchboard instruments and for a sample of Taut Band Suspension, write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. You can be sure . . . if it's Westinghouse.

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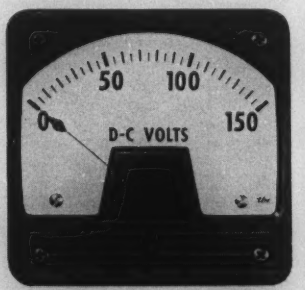

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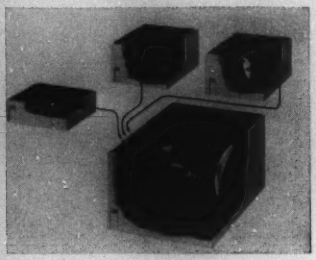
HUGHES

Industrial Notes...

Bell Aerosystems Co. Buffalo, N. Y...

Bell Aerosystems Company has been given a contract by the U. S. Air Force to study the feasibility of building a visual space flight simulator to prepare this country's astronauts for what they will see when they actually get out into space. Working with the Aerospace Medical Division of the U. S. Air Force, Bell has developed a



basic design for the simulator which will center about a theater containing the full-scale mockup of a space vehicle cabin. Closed-circuit television pictures, realistically depicting views that will confront the astronaut on a space mission, will be projected onto screens in front of each window of the space cabin. The space pictures will be staged in separate studios where models of the earth, moon, planets, stars, and other space vehicles will be viewed by television cameras transmitting to the theater screens. Movement of the studio cameras and models will be synchronized to correspond with the flight control actions taken by the astronaut in the space cabin.

Packard Bell Computer Corp. Los Angeles, Calif...

A new type of computing system, combining a digital computer and a unique differential analyzer, is being built for North American Aviation by Packard Bell Computer Corporation, a division of Packard Bell Electronics. The new system will be used by North American for more effective study of flight characteristics of the new triple-sonic Air Force B-70 before it ever leaves the ground. The hybrid computing system will include a *PB250* digital computer and a TRICE digital differential analyzer. The TRICE computer is a high-speed digital counterpart of analog computers, in wide use to solve dynamic system problems.

Ionics, Inc, Cambridge, Mass...

A 240-cubic-foot environment test chamber which can simulate the living conditions encountered by human occupants of submarines and space vehicles, was demonstrated recently by Ionics, Inc. The environment control simulator will be used in the design and testing of life support equipment now being developed by the company under government contract and on its own sponsorship. Medical and technical personnel will be sealed in the chamber for periods of several days or weeks. They will evaluate, under simulated operating conditions, the effectiveness of various components which remove waste carbon dioxide from the atmosphere, generate life-giving oxygen, and reclaim pure water from waste water in a closed system.

Allis-Chalmers Mfg. Co. Milwaukee, Wisc...

A fully instrumented test stand has been installed at Allis-Chalmers West Allis Works for continuous performance studies of thrust bearings for steam turbine-generator units. Capable of handling full-size thrust bearings, the new facility can be made to reproduce actual operating conditions of load, speed, lubricant temperature, and oil flow. Bearings can be tested to destruction if desired. Highest speed for turbine-generator units is 3,600 rpm. Power outputs have risen to 350 mw in single-shaft tandem-compound

units and to much higher figures for projected cross-compound types. Consequently, turbine thrust bearings are undergoing unprecedented development.

(Continued on page 43A)

Industrial Notes

(Continued from page 40A)

Chase Brass and Copper Co. Waterbury, Conn. . .

The first commercial production of rhenium-molybdenum alloys was announced recently by Chase Brass & Copper Company. This development will make available improved materials for use in many aerospace, electronic, and electrical applications. The successful alloying of rhenium and molybdenum is said to represent a combination of the best characteristics

of both metals. The alloys have better mechanical properties than either rhenium or molybdenum at considerably lower cost than pure rhenium. Elevated temperature strength exceeds that of molybdenum while very good ductility is retained all the way down to the cryogenic temperature range (to —450 F) without evidence of embrittlement.

Multi-Amp Electronic Corp. Union, N. J. . .

Multi-Amp Electronic Corporation announces the establishment of a Defense Products Division. The new division will specialize in design, development, and production of electronic and electromechanical equipment for military services. The Defense Products Division will be located at Multi-Amp's headquarters in Union, N. J.

Goodyear Tire and Rubber Co. Akron, Ohio . . .

A patent for a unique "wiggle-wire" de-icing element for removing ice from wings, propellers, and other airplane surfaces has been granted to The Goodyear Tire & Rubber Company. The new Iceguard introduces an exclusive and revolutionary feature in de-icing—a knitted electric element with 48 wires per inch. Important advantages are more uniform heating and ice melting. The increased efficiency also allows the new Iceguard system to operate with less power.

F. J. Stokes Corp. Philadelphia, Pa. . .

F. J. Stokes Corporation, Philadelphia, has established a subsidiary company in Great Britain, F. J. Stokes Ltd., with headquarters in London. The new British subsidiary will market several of Stokes' wide range of automatic machines and equipment for the chemical, automative, electronics and food industries throughout the British Isles, the Commonwealth, and countries of the European Free Trade Association.

RCA New York, N. Y. . .

The Tiros II weather satellite, competing several months of successful operation in space, flashed a signal to earth recently to touch off an explosive charge breaking ground for an advanced space environment center at the RCA division in Princeton, N. J., where the satellite was designed and built. The groundbreaking took place at the RCA Astro-Electronics Division Space Center, marking the start of construction on a multimillion-dollar engineering facility in which complete satellites and space vehicles will be tested under harsh environmental conditions similar to those they will encounter in outer space.

Kearfott Los Angeles, Calif. . .

Kearfott Division, General Precision, Inc., has announced the opening of a new plant facility in Los Angeles, Calif., which will consolidate engineering, production, sales, and administrative activities previously conducted at Pasadena. This new western region office, 9,000 square feet in area, is staffed by engineering and production

personnel engaged in the design and fabrication of precise electromechanical devices for ground support, missiles, and aircraft, and also serves as Kearfott's western region sales office.

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New Westinghouse Wescor core combines the improvements in quality and permeability of Hipersil® steel with a newly developed method of forming a series of step-lapped core joints. Result: higher possible working inductions in the magnetic circuit. In fact, core loss is 33% less than equivalent type C core . . . with comparably lower exciting current.

Wescor cores are pretested and shipped from stock in 27 sizes, ranging from 30 to 400 pounds. More details from your nearest Westinghouse representative, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. *Trademark

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Regular classified advertisements set solid—no display—minimum 5 lines: $3.00 per line. No agency commission or cash discount allowed. Situation Wanted classified advertising for AIEE members: $2.00 per line, minimum 5 lines. Address orders to: Classified Section, ELECTRICAL ENGINEERING, 6th Floor, 33 West 39th Street, New York 18, N. Y.

When answering an advertisement, send all replies to box number specified, c/o ELECTRICAL ENGINEERING, 6th Floor, 33 West 39th Street, New York 18, N. Y., unless other address is given.

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PROFESSOR OR ASSOCIATE PROFESSOR of Electrical Engineering to teach and do research in the field of communications. Should have Ph.D., teaching and research experience. Write Box 56.

TRANSFORMER ENGINEER. With experience in the design and development of Hi-Frequency and Pulse Transformers for commercial and military applications. Ideal opportunity for ambitious man to develop full potential of present small department. Salary—open. Location—Erie, Pennsylvania. Call or send resume to: Chief Engineer, Erie Electronics Division, Erie Resistor Corporation, 645 West 12th Street, Erie, Pennsylvania.

PROFESSORS, all levels. Ph.D. required. Solid-state, electromagnetics, and engineering analysis especially. Income, with research, competitive with industry. Graduate program as large as undergraduate. Mile-high, dry climate. Chairman, Electrical Engineering Department, University of New Mexico, Albuquerque, New Mexico.

INSTRUCTORS, Associates, Assistants for teaching and research part-time position while working for M.S. and D.Sc. Large graduate program assures variety of offerings. Chairman, Electrical Engineering Department, University of New Mexico, Albuquerque, New Mexico.

ELECTRICAL ENGINEERING TEACHING. Further expansion in a relatively young department provides attractive opportunities. Positions available to the rank of Associate Professor with salary range to $7500 on a base of nine months, commensurate with professional experience and graduate education. Supplementary professional opportunities are expected in a technical industrial area. Location: Southern New England. Box 132.

ELECTRICAL ENGINEER WITH SALES INCLINATIONS will be trained to join the sales staff of a reputable, fast growing firm in the transformer business. Excellent earnings, benefits, and potential. Call Jerry Frank at Uptown 1-9100. HEVI-DUTY ELECTRONIC COMPANY, 3002 West Burleigh Street, Milwaukee, Wisconsin.

ELECTRICAL ENGINEER, for design and development of transistorized circuits—in particular for static voltage regulators on AC and DC generators. Commercial and military applications. Salary based on experience and immediate value to company. Send complete resume in confidence to A. Beardmore, Safety Electrical Equipment Corp., 1187 Dixwell Avenue, New Haven 14, Connecticut.

MANUFACTURING ENGINEER, graduate EE or ME with minimum of 8 years experience in production of diversified electro-mechanical products including motors and generators to 500HP. Opportunity to advance rapidly to Plant Superintendent. Send complete resume in confidence to A. Beardmore, Safety Electrical Equipment Corp., 1187 Dixwell Avenue, New Haven 14, Connecticut.

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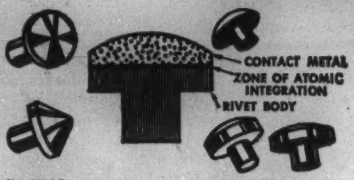

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A new process provides solid bonding by atomic integration of contact face metal and the rivet body, with superior electrical and mechanical bond. It permits substantial economy of precious metal by limiting its area and thickness to actual electrical and mechanical requirements of the contact, and ranges from a thin, centered elipse to complete envelopment of the rivet head. The entire rivet may be silver-plated at no extra cost.

Made in flat, radius, full crown or conical face of either precious or semi-precious metals. Shanks may be solid, indented or tubular; of copper, steel or other base metals.

- Contact facing is bonded directly and is integral with the rivet body without any contaminating layer of brazing material or flux.
- Better electrical, mechanical and thermal capacities.
- Surfaces are work-hardened through elimination of the annealing effect of brazing heat.
- Contact facing thickest where wear is greatest.
- Reduced bounce and chatter because of lower elasticity of copper body.
- Lighter weight an assist in delicate assemblies.

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